DRAFT

INTERIM ACTION FEASIBILITY STUDY

OLIN CHEMICAL SUPERFUND SITE
WILMINGTON, MASSACHUSETTS

Prepared for:

Olin Corporation
3855 North Ocoee Street; Suite 200
Cleveland, TN 37312

Prepared by:

Wood Environment & Infrastructure Solutions
271 Mill Road
Chelmsford, MA 01824

Project No. 6107190016

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LIST OF ACRONYMS and ABBREVIATIONS

1,2-DCA	1,2-dichloroethane
AMEC	AMEC Environment & Infrastructure, Inc.
Amec Foster Wheeler	Amec Foster Wheeler Environment & Infrastructure, Inc.
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
BEHP	Bis-2-ethylhexyl phthalate
BERA	Baseline Ecological Risk Assessment
BHHRA	Baseline Human Health Risk Assessment
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cis-1,2-DCE	Cis-1,2-dichloroethene
cm/sec	centimeters per second
CMR	Code of Massachusetts Regulations
COC	Chemical of Concern
COI	Chemical of Interest
CSL	Calcium Sulfate Landfill
CSM	Conceptual Site Model
DAPL	Dense Aqueous Phase Liquid
ESTCP	Environmental Security Technology Certification Program
FFS	Focused Feasibility Study
FS	Feasibility Study
ft	Foot or feet
ft msl	Feet above mean sea level
GCL	Geosynthetic clay liner
GEI	Geotechnical Engineers, Inc.
gpd	Gallons per day
gpm	Gallons per minute
HDPE	High density polyethylene
HI	Hazard Index

HQ	Hazard Quotient
IAFS	Interim Action Feasibility Study
IAO	Interim Action Objective
LNAPL	Light Non-Aqueous Phase Liquid
MACTEC	MACTEC Engineering and Consulting, Inc.
MassDEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level
MCP	Massachusetts Contingency Plan
µg/L	Micrograms per liter
µmhos/cm	Micro-ohms per centimeter
mg/L	Milligrams per liter
MMB	Maple Meadow Brook
MPE	Multi-phase extraction
MWRA	Massachusetts Water Resource Authority
MWSW	Municipal Water Supply Well
NAPL	Non-Aqueous Phase Liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NDMA	N-nitrosodimethylamine
NDPA	N-nitrosodiphenylamine
ng/L	Nanograms per Liter
NPL	National Priorities List
OCSS	Olin Chemical Superfund Site
off-PWD	Off-Property West Ditch
Olin	Olin Corporation
O&M	Operations and maintenance
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
ORP	Oxidation-reduction potential
OU	Operable Unit
PCMP	Post-Construction Monitoring Plan
PRG	Preliminary Remediation Goal
Property	Olin Property
PVC	Polyvinyl chloride
RAM	Release Abatement Measure

RCRA	Resource Conservation and Recovery Act
RGP	Remediation General Permit
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
RSL	Regional Screening Level
SASR	Semi-Annual Status Report
the Site	Olin Chemical Superfund Site
SOW	Statement of Work
SVOC	Semivolatile organic compound
TCE	Trichloroethene
TMP	Trimethylpentenes
UCL	Upper Concentration Limit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UV	Ultraviolet
VC	Vinyl chloride
VOC	Volatile organic compound
WBV	Western Bedrock Valley

EXECUTIVE SUMMARY

This Interim Action Feasibility Study (IAFS) has been prepared by Olin Corporation (Olin) for four specific proposed interim actions that are related primarily to Operable Unit 3 (OU3) which is the groundwater operable unit and also to Operable Unit 1 (OU1) which is the on-Property soil, surface water, and sediment operable unit of the Olin Chemical Superfund Site (OCSS) in Wilmington, MA. This IAFS has been prepared to support actions that are prudent, that can be implemented in a time frame that is likely much shorter than the time frame required to achieve a permanent remedy, that will result in reduction of volume and mass of hazardous materials and that will be consistent with the goal of the National Contingency Plan and of protection of human health and the environment. The proposed interim actions, consistent with USEPA guidance, will stabilize the site and prevent further migration of contamination as appropriate.

Note, in addition to this IAFS, additional related documents will be submitted to USEPA in the near future that evaluates remedial alternatives for the Site. A. The Draft Final OU1/OU2 FS will be submitted by May 24, 2019. This will be a revision of the Draft OU1/OU2 FS submitted previously on March 30, 2018 and will be based on USEPA's comments on the Draft OU1/OU2 FS. The revised Draft OU3 Remedial Investigation (RI) Report is in preparation and will be submitted to USEPA by June 28, 2019.

As discussed during several meetings between Olin and USEPA, between December 2018 and March 2019, this IAFS has been developed based on information available currently. However, as additional investigation and data collection is performed that will be useful in developing the design details for one or more of the proposed interim actions, the alternatives recommended in this IAFS may be reassessed if necessary to ensure its effectiveness. This IAFS does not replace the more formal and comprehensive future FS for all of OU3. While the proposed interim actions may be components of a final remedy, it should be clear that the proposed interim actions are not intended to represent a final Site-wide remedy.

The following Interim Action Objectives (IAOs) have been developed for the four proposed interim actions. Such objectives would typically be referred to as "Remedial Action Objectives," but are referred to herein as IAOs for the sake of context. Remedial objectives for the Draft Final OU1/OU2 FS will presented in that document.

- Enhance the recovery of Light Non-Aqueous Phase Liquid (LNAPL) from the subsurface at the Plant B groundwater recovery and treatment system.

- Reduce, to the extent practicable, volume of Dense Aqueous Phase Liquid (DAPL) and mass of constituents in the three DAPL pools (On-Property, Off-Property West Ditch, and Main Street DAPL Pool) that represent a source of constituents to groundwater and surface water.
- Manage downgradient migration of higher-concentration groundwater within the Ipswich Watershed.
- Take actions towards hydraulic isolation of the Containment Area and to insure the continued inaccessibility of soils.

The following interim action alternatives have been developed and evaluated in this IAFS to address the above-listed concerns and identified IAOs.

As requested by USEPA, each of the recommended interim actions is based on a range of alternatives that consider differing degrees of aggressiveness in achieving IAOs. For LNAPL, this was accomplished by looking at different LNAPL removal technologies and locations. For DAPL, different combinations of extraction wells and pumping rates were considered to achieve extraction rates commensurate with expected gravity drainage rates. Downgradient management of groundwater migration considered different extraction well locations and rates; note, this will require refinement during the design phase. For the Containment Area, previously evaluated cap systems were re-considered and modified to develop a hydraulically effective cap that would provide appropriate performance and survivability while addressing the concerns raised by USEPA. Soil removal was also considered for the Containment Area. Section 3 provides additional discussion on ranges of alternatives considered in development of the IAFS alternatives.

Enhance LNAPL recovery

- Alternative LNAPL 1: No Action
- Alternative LNAPL 2: Manual Recovery
- Alternative LNAPL 3: Continual Mechanical Recovery
- Alternative LNAPL 4: Multi-Phase Extraction

Reduce DAPL volume and mass of DAPL constituents

- Alternative DAPL 1: No Action
- Alternative DAPL 2A: DAPL Extraction from Off-PWD DAPL Pool

- Alternative DAPL 2B: DAPL Extraction from On-Property (Containment Area) DAPL Pool
- Alternative DAPL 2C: DAPL Extraction from Main Street DAPL Pool

Manage downgradient migration of higher-concentration of NDMA in groundwater in the Ipswich Watershed

- Alternative GW 1: No Action
- Alternative GW 2A: Groundwater Extraction via MWSWs with Treatment for Potable Use by Additions to Municipal Water Treatment Plant
- Alternative GW 2B: Groundwater Extraction via MWSWs with Treatment for Surface Water Discharge by Additions to Municipal Water Treatment Plant
- Alternative GW 3: Groundwater Extraction via New Wells and Treatment via New Water Treatment Plant for Surface Water Discharge
- Alternative GW 4: Groundwater Extraction via Butters Row MWSWs and Treatment via New Water Treatment Plant for Surface Water Discharge
- Alternative GW 5: Groundwater In-Situ Biological Treatment

Take actions towards hydraulic isolation of the Containment Area and insure continued inaccessibility of soil

- Alternative CA 1 1: No Action
- Alternative CA 2: Capping, Elimination of the Equalization Window, and Continued Institutional Controls
- Alternative CA 3: Soil Removal

Based on the comparative analysis of alternatives presented in this FS, Olin has identified the following recommended alternatives:

Enhance LNAPL recovery

- Alternative LNAPL 2: Manual Recovery

Reduce DAPL volume and mass of DAPL constituents

- Alternative DAPL 2A (DAPL Extraction from off-Property DAPL Pool);
- Alternative DAPL 2A (DAPL extraction from on-Property DAPL Pool); and
- Alternative DAPL 2A (DAPL Extraction from Main Street DAPL Pool)

Manage downgradient migration of higher-concentration of NDMA in groundwater in the Ipswich Watershed

- Alternative GW 2A: Groundwater Extraction via MWSWs with Treatment for Potable Use by Additions to Municipal Water Treatment Plant

Take actions towards hydraulic isolation of the Containment Area and insure continued inaccessibility of soil

- Alternative CA 2: Capping, Elimination of the Equalization Window, and Continued Institutional Controls

1.0 INTRODUCTION

This Interim Action Feasibility Study (IAFS) has been developed to provide USEPA with an evaluation of remedial alternatives that will address on-going sources of impacts to groundwater at the Olin Chemical Superfund Site (Site) as well as migration of impacts at elevated concentrations in downgradient groundwater. This IAFS is a result of significant discussion between the USEPA and Olin and represents a cooperative approach to addressing environmental concerns at the Site. This IAFS also follows submittal of several significant documents as described below.

A Final Remedial Investigation (RI) Report (AMEC Environment & Infrastructure, Inc. [AMEC], 2015) has been developed by Olin Corporation (Olin) and approved by the United States Environmental Protection Agency (USEPA) (USEPA, 2015) for Operable Units 1 and 2 (OU1 and OU2) at the Olin Chemical Superfund Site (OCSS) in Wilmington, MA.

In March 2018, the following documents associated with Operable Unit 3 (OU3; Site-wide groundwater), and OU1 (on-Property soil, surface water, and sediment) and OU2 (off-Property surface water and sediment) were submitted to the USEPA:

- Draft OU3 RI Report
- Draft OU3 Baseline Human Health Risk Assessment (BHHRA)
- Draft OU1/OU2 Feasibility Study (FS)
- Draft OU3 FS

The USEPA provided comments on the above-listed documents in a September 25, 2018 letter. Consistent with those comments, the revised Draft OU3 BHHRA was submitted on December 18, 2018. Olin provided responses to the September 25, 2018 USEPA letter on January 2, 2019.

USEPA met with Olin on December 10, 2018 to discuss comments and concerns raised by the USEPA on aspects of the conceptual site model and data gaps. As a result of the December 10, 2018 meeting and subsequent discussions, Olin agreed to prepare this Interim Action FS (IAFS) to evaluate interim action alternatives to 1) enhance recovery of light non-aqueous phase liquid (LNAPL), 2) reduce volume and mass of Dense Aqueous Phase Liquid (DAPL), 3) manage downgradient migration of higher-concentration of N-nitrosodimethylamine (NDMA) in groundwater in the Ipswich Watershed, and 4) to hydraulically isolate the Containment Area. Note, as discussed and mutually agreed by Olin and USEPA, the alternatives associated with a final remedy for OU3 groundwater will be addressed in a future Groundwater FS after additional site investigation data has been collected and evaluated.

On March 8, 2019 USEPA provided responses to Olin's responses to the September 25, 2018 comment letter referred to above, including specific comments on the revised Draft OU3 BHHRA. The comments on the revised BHHRA were primarily related to inclusion of USEPA's perspective where there are differences of opinion concerning various topics and USEPA's comments generally concurred with the revised BHHRA and its conclusions. The March 8, 2019 letter also stated "EPA and Olin agree that development of an Interim Action Feasibility Study ("IAFS") shall proceed, and that differences between Olin and USEPA's Conceptual Site Model (CSM) can be discussed in the pending remedial investigation for groundwater OU3."

This IAFS has been developed in parallel with additional site investigations and revisions to the OU3 RI, including the BHHRA. A portion of the IAFS will identify interim actions intended to enhance recovery of subsurface LNAPL from the Plant B Area, where recovery of LNAPL is ongoing. The portion of this Draft IAFS that addresses reduction of volume and mass of DAPL will address the On-Property DAPL Pool (within the Containment Area), the Off-Property West Ditch (Off-PWD) DAPL Pool and the Main Street DAPL Pool. The management of downgradient migration of higher-concentration NDMA in groundwater in the Ipswich Watershed is addressed in this IAFS. The alternatives associated with a final remedy for OU3 groundwater will be addressed in a future Groundwater FS after additional site investigation data has been collected and evaluated, and the USEPA and Olin more closely agree on the CSM for the OCSS. The Containment Structure currently is covered by a temporary cap. This IAFS evaluates possible interim actions (such as permanent capping and soil removal) that may contribute to and facilitate achievement of a permanent remedy for the Containment Area. The final remedy for the Containment Area will likely be addressed in further FS activity for OU1 and OU3.

1.1 Purpose, Scope and Report Organization

1.1.1 Purpose and Scope

As agreed upon between the USEPA and Olin during the December 10, 2018, the purpose of this document is to develop, evaluate and propose interim action alternatives for OU3, to enhance recovery of LNAPL at the Plant B area, to reduce the volume and mass of DAPL, manage migration of higher-concentration groundwater (NDMA concentrations greater than 11,000 ng/L) in the Ipswich Watershed and to address hydraulic isolation and impacted soils within the Containment Area. As stated previously, remedial alternatives to address all OU3 groundwater that requires remediation will be addressed in a future Groundwater FS.

This IAFS develops and presents interim action alternatives in a manner consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CPR Part 300), and

Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Office of Solid Waste and Emergency Response [OSWER] Directive 9355.3-01). The alternatives presented in this document are developed by assembling combinations of technologies into alternatives that address source control and management of migration.

The scope of this IAFS is commensurate with the approach outlined in the USEPA Guide to developing Superfund No Action, Interim Action, and Contingency Remedy RODs (USEPA, 1991a). That USEPA guidance indicates that an Interim ROD (and an IAFS, by inference) should be tailored to the scope and purpose of the interim action.

The 1991 guidance states: "Although preparation of an RI/FS is not required for an interim action, for the purpose of fulfilling the NCP's Administrative Record requirements, there must be documentation that supports the rationale for the action".

1.1.2 Report Organization

The remainder of Section 1.1 presents background information concerning the LNAPL recovery at the Plant B Area, the three DAPL pools, the groundwater contamination in the Ipswich Watershed, and the Containment Area, including a brief summary of past response actions. This is followed by a summary of the nature and extent of contamination and fate and transport for OU3 as they relate to the interim actions that are developed and proposed in this IAFS.

Section 2 discusses the interim action objectives (IAOs) and the identification and screening of technologies. The term IAOs is simply being used in lieu of the more typical term "RAOs" to be consistent with the interim scope of this document. This section also discusses the groundwater COCs for future potable use of groundwater, and ARARs as they relate to implementation of the interim actions. Section 2 then develops the general response actions to meet the IAOs and identifies technologies specific to LNAPL, DAPL, impacted groundwater, and the Containment Area. Those technologies are then screened for feasibility and implementability. Candidate technologies that meet screening criteria are retained for development of alternatives.

Section 3 presents the development and screening of alternatives and evaluates each alternative individually for effectiveness, implementability and cost.

Section 4 provides a streamlined analysis of the interim action alternatives, followed by a comparative analysis of the alternatives. The comparative analysis of alternatives evaluates each alternative against seven of the nine evaluation criteria, as applicable.

Section 5 presents a summary of the recommended alternatives.

Section 6 contains references.

1.2 Background Information

The OCSS is located at 51 Eames Street in Wilmington, Massachusetts (**Figure 1.2-1**), and is comprised of the Olin Property (Property), an approximate 50-acre parcel, and adjoining off-Property areas impacted by historic manufacturing operations at the Property. A chemical manufacturing facility ("facility") was formerly located within the northern portion of the property.

Manufacturing activities were conducted at the OCSS from 1953 until 1986, when all manufacturing operations ceased. Olin purchased and began operating the facility in 1980. From 1953 onward, the facility expanded incrementally (additional buildings were constructed) as additional products and processes were added and as processes were modified. The facility produced chemical products for use in the rubber and plastics industry. Additional information regarding the history of the OCSS, including Massachusetts Contingency Plan (MCP) and CERCLA response actions, is presented in the previously approved Final OU1 and OU2 RI Report (AMEC, 2015).

The OCSS was listed on the National Priorities List (NPL) pursuant to CERCLA Section 105, 42 U.S.C. 9605 on April 19, 2006 (71 FR 20,016). NDMA was the primary substance used by the USEPA to score the OCSS (USEPA, 2005) in September 2005 when it was proposed for the NPL. The primary exposure pathway scored by USEPA was potable use of groundwater. Prior to the NPL listing, the OCSS had been the subject of many years of investigations and response activities carried out by Olin, and supervised by Massachusetts Department of Environmental Protection (MassDEP) under Chapter 21E of the General Laws of Massachusetts and the MCP. The OCSS has been a Priority site under the MCP since 1993, and a Tier I site since 1994.

Olin Corporation, American Biltrite Inc. (and The Biltrite Corporation), and Stepan Company, as Co-Respondents, voluntarily entered into an Administrative Settlement Agreement and Order on Consent (AOC) with the USEPA to conduct an RI/FS for the OCSS (USEPA, 2007a) on July 3, 2007. The Scope of the RI/FS is described in the Statement of Work (SOW) as prepared by the USEPA Region I – New England and dated June 28, 2007 (USEPA, 2007b).

USEPA has subdivided the OCSS into three OUs, as defined in the AOC/SOW, and are described as follows:

OU1: Approximately 50-acre Olin Property including the former facility area, the established conservation area, the on-Property ditch system, the Calcium Sulfate Landfill (CSL), and the Slurry Wall Containment Area. The RI/FS evaluated soil (including vadose zone soil), surface water, sediment and potential vapor intrusion into OU1 buildings. Note, soils located within the water table will be evaluated in the groundwater RI/FS for OU3.

OU2: Off-Property surface water and sediment areas, including, the off-Property East Ditch, a small portion of the South Ditch, the off-Property West Ditch (off-PWD), and portions of the Maple Meadow Brook (MMB) Wetland. Note, North Pond and Landfill Brook were investigated as part of OU2 and were found not to be part of the OCSS (MACTEC, 2007).

OU3: On- and off-Property groundwater areas including groundwater beneath the Olin Property, MMB aquifer, and groundwater located south and east of the Olin Property. Soils located within the water table will also be evaluated under OU3.

Figure 1.2-2 identifies the Ipswich and Aberjona watersheds and the locations of the Plant B treatment building, the three DAPL pools, the Containment Area and other relevant site features.

The OCSS was listed on the NPL in 2006, primarily due to the presence of NDMA in groundwater within the MMB aquifer near five of the Town of Wilmington's Municipal Water Supply Wells (MWSW). These supply wells were shut down in 2003 when NDMA was first detected in groundwater samples collected in this area. The wells have not been used as a potable water source since that time. Olin and the other respondents funded approximately $4,500,000 to connect the Town of Wilmington to the Massachusetts Water Resource Authority (MWRA) to replace the potable water historically provided by the MWSWs. The Town of Wilmington continues to use the MWRA connection; approximately 550,000 gallons per day were used in 2016. The USEPA review comments on the Draft OU3 FS, indicate that the Town of Wilmington continues to maintain the MWSW with the intent of re-activating these wells, if appropriate, in the future.

1.3 Site Description

The OCSS encompasses the Property and surrounding areas where contaminants have migrated via surface water, sediment, and/or groundwater transport. The Property is bounded on the east by the Massachusetts Bay Transit Authority tracks, on the south by the Woburn/Wilmington Town Line, on the west by an inactive Boston and Maine Railroad spur, and on the north by Eames Street (see **Figure 1.2-2**). The Property is located in an industrialized area of Wilmington within a General Industrial zone. Intensive industrial land use occurs on the eastern, northern and western sides of the Property. The southern side of the property is bounded by the Woburn Sanitary Landfill, a former municipal solid waste landfill that has been closed. Residential properties are located along Main Street and Cook Avenue located to the west of the Property and along Eames Street before it intersects with Woburn Street. OCSS features are shown on **Figure 1.3-1**. Additional detailed information about the Olin Property is presented in the OU1 and OU2 RI Report (AMEC, 2015), Draft Focused DAPL RI Report (Amec Foster Wheeler, 2017a), and in the Draft OU3 RI Report (Amec Foster Wheeler, 2018a).

The former facility was located on the northern half of the Property, which is currently unused and contains a vacated office building, a small metal butler building, a former guard shack, two vacant warehouses, paved and grassed areas, and concrete slabs from other former buildings (see **Figure 1.3-1**). In 2006, for Site maintenance and management purposes, Olin installed a 40-foot office trailer and two metal storage trailers in the north eastern portion of the Property, near the Plant B groundwater recovery/treatment system.

Site features relevant to the interim actions addressed in this IAFS are described below. There is also documentation of the need for interim actions to address those features.

1.3.1 Plant B Groundwater Recovery/Treatment System.

The Plant B groundwater recovery/treatment system has been in operation since 1981 with continued operation from 1997 to 2006 as an Immediate Response Action under the MCP and from 2006 to date as an Interim Response Steps Measure under CERCLA. The system is located at the northeast corner of the 51 Eames Street property as shown on **Figure 1.2-2** and described in more detail below**.**

The system was installed to prevent seepage of a light non-aqueous phase liquid (LNAPL) into the East Ditch, which is located along the eastern perimeter of the former facility. The LNAPL is a mixture of process oil and other raw materials historically stored and used at the Facility, including Bis-2-ethylhexyl phthalate (BEHP), Trimethylpentenes (TMPs), and N-nitrosodiphenylamine (NDPA), and were released during operations of former property owners prior to Olin's ownership. The Plant B system's primary purpose is to control the migration of LNAPL by maintaining a cone of depression. On average, approximately 1 to 2 gallons of LNAPL is removed annually. Groundwater extracted by the system is treated to remove iron and ammonia, as well as dissolved organic compounds. The treated groundwater is discharged to surface water on-Property in compliance with a Remediation General Permit (RGP). The most current RGP was issued on June 26, 2018.

During its history of Plant B treatment system operation, additional measures including air sparging with soil vapor extraction and nutrient addition for biological stimulation have been implemented to reduce the mass of TMPs and BEHP. Plant B falls within the current Zone II of the public water supply wells, but based on the available data, the groundwater flow path from Plant B is not anticipated to cause an impact to any of the five existing public water supply wells in MMB. The LNAPL is considered a source of dissolved phase contaminants to groundwater which may discharge to East Ditch, and enhanced recovery of the LNAPL is evaluated in this IAFS as a source control measure.

1.3.2 DAPL Pools

DAPL is a highly concentrated brine, typically dark green (almost black) in color, with a low pH, and density slightly greater than water. The definition of DAPL is based on having a specific gravity greater than 1.025 which can be estimated by an empirical formula based on its primary constituents. In general, DAPL at OCSS exhibits the following concentrations of major constituents, but these concentrations by themselves do not define DAPL (they simply imply a density prediction):

- Ammonia concentration greater than 1,250 milligrams per liter (mg/L);
- Chloride concentration greater than 2,800 mg/L;
- Magnesium concentration greater than 270 mg/L;
- Sodium concentration greater than 1,700 mg/L;
- Sulfate concentration greater than 16,000 mg/L; and
- Specific conductance greater than 20,600 micro-ohms per centimeter (µmhos/cm).

In the absence of specific gravity data, specific conductance has been used as an indicator to discriminate DAPL samples from diffuse layer groundwater samples. Olin has committed to re-evaluating this empirical formula to predict density following receipt of groundwater data currently being gathered and developed.

In accordance with various USEPA guidance documents (USEPA, 1991b and 1999), "source material" is defined as material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water, to air, or acts as a source for direct exposure. Contaminated groundwater is not considered to be a source material, although non-aqueous phase liquids (NAPLs) may be viewed as source materials. Pools of dense NAPLs; or in the case of the OCSS, DAPL; are considered source materials. Hence, source control interim actions are being identified and evaluated for the three DAPL pools.

DAPL has been identified in pools residing in bedrock depressions beneath the Olin Property (on-Property DAPL Pool), immediately west of the Olin Property (off-PWD DAPL Pool), and further to the west near Main Street (Main Street DAPL Pool). The aerial extent of the three DAPL pools is shown on **Figure 1.3-1**.

A DAPL Extraction Pilot Test (Pilot Test) was conducted from 2012 – 2014 to evaluate the feasibility of DAPL extraction in the off-PWD DAPL Pool area. The Pilot Test results and data evaluation are presented in the DAPL Extraction Pilot Study Performance Evaluation Report (AMEC, 2014), which concluded that DAPL extraction is feasible if the pumping rate does not exceed the gravity drainage rate of the DAPL (less than 0.5 gallons per minute [gpm]). The limitation on pumping rates is explained further in Section 4.2.1. Olin has voluntarily extracted DAPL from a single extraction well (EW-1) from the off-PWD DAPL Pool area since beyond the duration of the Pilot test. To date, approximately one million gallons have been extracted and disposed off-site.

1.3.3 Impacted Groundwater Ipswich Watershed

The investigations to date have documented Site-related impacts to overburden and bedrock groundwater at the 51 Eames Street property and primarily in areas to the west and north of the property in the Ipswich Watershed). The Ipswich Watershed includes the zone of contribution for five inactive Town of Wilmington Municipal Water Supply Wells (MWSWs) and numerous private residential bedrock drinking water wells. The MWSWs have been inactive since March of 2003 due to the detection of NDMA in samples from four of the five MWSWs at concentrations above the MassDEP Office of Research and Standards Drinking Water Guideline of 10 ng/L. Inorganic constituents associated with DAPL (calcium, chloride, sulfate, ammonia, sodium, and magnesium) and arsenic and cobalt have also been detected at elevated concentrations in overburden and bedrock groundwater in the Ipswich Watershed and zone of contribution to the MWSWs.

The cores of the overburden and bedrock groundwater plumes are located to the northwest of the 51 Eames Street property and south of the inactive Butters Row MWSWs and east of the inactive Chestnut Street MWSs as shown in **Figures 1.3-2 and 1.3-3**. Monitoring wells representative of the overburden groundwater plume cores include GW-84S, M, and D, GW-85D, GW-86D, and GW-87D and GW-61BR, GW-62Br and BRD, MP-5 (Port 3), GW-103BR, and GW-65BR, BRDS, and BRDD are representative of the bedrock groundwater plume core.

The overburden groundwater beneath the Maple Meadow Brook wetland flows to the north along a bedrock valley and the surface water from the Maple Meadow Brook wetland also flows to the north and subsequently flows in to the Ipswich River.

The extent of the overburden and bedrock groundwater plumes is defined by presence/absence of NDMA, which appears to be the most mobile of the groundwater contaminants. The NDMA is also the most substantial contributor to health risk for the hypothetical future potable use of groundwater from the core of the overburden and bedrock plumes. Recent monitoring of groundwater indicates that NDMA has migrated beyond the location of the GW-65 overburden and bedrock monitoring wells that are located at the northern end of the Maple Meadow Brook wetland. A localized "hot spot" of NDMA in groundwater downgradient of the Main Street DAPL pool exists that is defined by an NDMA concentration of 11,000 ng/L. USEPA has requested that we evaluate alternatives to manage migration of impacted groundwater downgradient of this high NDMA concentration area. As requested, this IAFS evaluates migration mitigation along with management of the DAPL source areas.

1.3.4 Containment Area

Lined Lagoons. Olin ceased operations and completed closure of the Lined Lagoons as part of the closure activities initiated in 1986 (MACTEC, 2007) and completed in accordance with closure plans approved by MassDEP. The calcium sulfate in the lagoons and the lagoon liners were removed and placed in the CSL. The CSL was then covered with a low permeability cap in 1988, and received final closure certification in accordance with the Massachusetts Solid Waste Management Regulations (310 Code of Massachusetts Regulations [CMR] 19.000). The location of the former Lined lagoons is shown on **Figure 1.3-1**.

A Slurry Wall/Containment Structure (Containment Area) was constructed in 2000/2001 as a Release Abatement Measure (RAM) while the OCSS was regulated under the MCP. The location of the Slurry Wall/Containment Area is shown on **Figure 1.2-2**. The purpose of the Slurry Wall/Containment Structure was to eliminate, to the extent feasible, the on-Property DAPL pool from being a source of dissolved constituents to groundwater by containing, to the extent possible, the DAPL and impacted groundwater in contact with the DAPL. The containment structure is comprised of a 3-foot wide soil-clay perimeter slurry wall that was installed into the bedrock surface to the extent feasible. This is depicted on the As-Built Construction Drawings provided in Appendix G of the Part 2 Construction-Related RAM Status Report No. 8 (GEI, 2004). The Containment Structure is currently covered by a temporary cap of 8-mil polyethylene sheeting. The temporary cap was not designed to minimize infiltration to the maximum extent possible, but rather to reduce infiltration by directing precipitation away from the Containment Area through an internal drain leading to a storm water retention basin.

A permanent deed restriction has been placed on the property that prohibits disturbing the soils within the Containment Area and underlying the temporary cap, and thereby limits future exposure to those soils. A copy of the Declaration of Restrictive Covenant for the Containment Area and CSL along with the Environmental and Open Space Restriction (environmental conservation deed restriction) was provided in the Final OU1 /OU2 RI Report (Amec Foster Wheeler, 2015).

The Containment Area is the subject of two separate proposed interim action scenarios: first, extraction of DAPL from within the Containment Area (on-Property DAPL pool) as a source control measure (one of three DAPL pools evaluated for potential extraction); and second, in order to facilitate achievement of a final remedy for the area, evaluation of the regulatory status of soils remaining in the Containment Area as well as an evaluation of alternatives to the soils in the context of a potential source to groundwater and an evaluation of the type of permanent cap that is appropriate.

Prior to slurry wall construction, design borings were installed around the perimeter to the top of bedrock to determine the slurry wall alignment. Next, the alignment was graded, and a level working platform with a width of 45 to 60 feet (ft) was constructed. The construction sequence began at the shallowest depth to bedrock to allow for a shorter lead-in trench. Construction was by continuous mud wave methods: a trench was excavated into bedrock until refusal and kept open by a bentonite slurry during excavation. The alignment borings were initial targets for depth to bedrock; however, where weathered bedrock was encountered at excavation, several additional feet of bedrock were typically excavated to ensure the slurry wall connected to more competent bedrock. Although some weathered bedrock was encountered above the competent bedrock, it does not affect the ability of the competent bedrock to impart a barrier to DAPL migration, similar to having a transmissive sand and gravel unit overlying the bedrock.

Based on pre-construction laboratory testing, the soil/bentonite backfill slurry was a mixture of native soil mixed with 30 percent (%) clay borrow, 3% attapulgite clay and 2% bentonite clay by weight. Permeability tests of the backfill slurry confirmed permeabilities ranged from 1.9 E-08 to 8.7 E-08 centimeters per second.

A water table equalization window within the slurry wall allows the groundwater surface within and outside the slurry wall to equilibrate. The window, approximately 50 feet long and 8 feet deep, was installed on the west side of the Slurry Wall Containment Area and consists of crushed stone backfill that extends about 3 feet below the groundwater table.

As discussed in the Draft OU3 RI Report (Amec Foster Wheeler, 2018a) and shown on **Figure 1.3-2**, the highest elevation of the DAPL pool within the Slurry Wall Containment Structure is observed at an elevation of approximately 53 feet above mean sea level (ft msl); the top of the diffuse groundwater is at an elevation of approximately 59 ft msl. The downgradient (southern) side of the Slurry Wall is located approximately 150 ft south of the DAPL Pool boundary, and, in this location the bedrock surface rises to an elevation of approximately 75 ft msl. Therefore, the southern side of the DAPL Pool, including the overlying diffuse layer, is contained by bedrock at elevations of approximately 53 and 59 ft msl, respectively, and is not in contact with that side of the Slurry Wall (at approximately 75 ft msl, located 150 ft further to the south). The groundwater equalization window is in the northwest part of the wall at 75 to 83 ft msl with a length of 40 feet (GEI, 2004). Olin continues to believe, based on the data available currently, that the bedrock underlying the containment wall is competent. However, DAPL management has been evaluated in this IAFS at USEPA's insistence.

A Post-Construction Monitoring Plan (PCMP) is being implemented for the Slurry Wall Containment Area and the temporary cap. The PCMP assesses the following: (1) Performance of the subsurface containment structure in encompassing the DAPL and diffuse groundwater, and (2) the temporary cap's performance in minimizing the influx of precipitation and storm water to the containment structure. Semi-annual status reports have been prepared since 2001 to document PCMP monitoring. Conclusions and observations of the PCMP monitoring to date include the following:

- Water levels monitored within the Containment Area indicate that the horizontal hydraulic gradient within the Containment Area is very flat and varies depending on well pairs compared and season. For example, calculated gradients perpendicular to interpreted equipotential lines in August and December 2013 varied from 0.0007 ft/ft to 0.0009 ft/ft respectively and in May and September 2017 were 0.002 ft/ft.
- Vertical gradients within the Containment Area have also remained essentially neutral since 2001;
- The equalization window is functioning as designed to relieve any buildup of hydraulic pressure inside the slurry wall; and,
- The relatively flat internal gradients and lack of vertical gradients with the structure indicate the slurry wall is effectively isolating groundwater above the DAPL from groundwater outside the Containment Area.
- The Containment Area is performing as designed as a source control measure for the on-Property DAPL Pool to minimize migration of impacted groundwater.
- Groundwater quality in adjacent wells (including GW-202D) and South Ditch surface water has been improving. These improvements to groundwater quality are believed to have resulted from combined effects DAPL extraction at the Off-PWD DAPL pool which has lowered the diffuse layer, construction of the Containment Area and are coincident

cessation of pumping from the Sanmina wells, which to our understanding, occurred in September in 2004.

Construction of the Slurry Wall Containment Area and the temporary cap are documented in the Part 2 Construction-Related RAM Status Report No. 8 submitted to the MassDEP September 4, 2004. The RAM was successfully completed to achieve the objective to contain residual DAPL and significantly contaminated groundwater within a subsurface containment system (slurry wall) to reduce the discharge of contaminated groundwater, and therefore mitigate the impact on surface water and sediments in the on-Property Ditch System. The Part 2 Construction-Related RAM Status Report No. 8 was subsequently approved by the MassDEP by letter dated March 29, 2005. The MassDEP approval letter acknowledged that the installation of the slurry wall to contain the on-Property DAPL, the temporary cap over the Containment Area, and the PCMP to monitor the effectiveness of the RAM. The letter also acknowledged that monitoring under the PCMP should continue to evaluate the effectiveness of the containment system and inspection and maintenance of the temporary cap should continue until such time that a permanent cap is designed and installed. The letter indicates that "DEP approves the completion of the Construction-Related RAM, including the recommended modifications to the PCMP and the reuse of the biocell sand," while further concluding that additional actions in other areas would be required to reach a Permanent Solution (for the entire site).

Considering the objectives of the containment area given above, monitoring data continue to be collected on a quarterly basis at surface water sampling locations in South Ditch and reported in Semi-Annual Status Reports (SASRs) submitted to the USEPA. Based on monitoring data presented in SASR No. 23, South Ditch surface water concentrations for chromium and ammonia (risk drivers identified in the USEPA-approved OU1/OU2 RI Report) have consistently been below the corresponding risk-based PRGs developed during the Baseline Ecological Risk Assessment (BERA) since 2015. These recent declines in chromium and ammonia concentrations suggest a long-term pattern and trend; however, continued monitoring should be conducted to confirm this dynamic. The data also suggests that construction of the Containment Area combined with DAPL extraction in the off-PWD DAPL Pool have improved, and will continue to improve, South Ditch surface water quality. South Ditch surface water is discussed further in Subsection 1.4.3.

Historically, prior to construction of the Slurry Wall Containment Structure, a RAM was conducted to investigate and remediate three areas within the Containment Area. Those three areas are Drum Area A, Drum Area B, and the Buried Debris Area. These areas are identified in **Figure 1.3-1**. The southern portion of the 51 Eames Street property were investigated with a magnetometer survey and sample collection and analysis from soil borings. Approximately 3,000 cubic yards of topsoil were stripped from the Containment Area. That soil was stockpiled, sampled and analyzed, and the data were used to demonstrate the soils were suitable for on-site uplands re-use (with MassDEP approval of that demonstration). Those topsoils remain stockpiled at the site.

Following the investigation activities referenced above, the two drum areas and the Buried Debris Area were remediated. The remedial actions included excavation and removal of drums, drum parts, drum contents, and soils from the drum areas and excavation of debris and soil from the Buried Debris Area. The drums, drum parts, and drum contents from the drum areas were disposed off-site mostly as non-hazardous solid waste (some material was disposed as hazardous waste). Excavated soils from the drum areas were segregated based on visual observations and field screening and were stockpiled. Some soils were disposed off-site as non-hazardous solid waste based on visual observation and field screening (from Drum Area A only). The stockpiled soil was sampled and analyzed to determine re-use options and/or disposal requirements. Confirmatory samples from the bottom and sidewalls of the excavations were also analyzed to confirm that MCP Upper Concentration Limits (UCLs) had been achieved (the stated objective of the RAM) by the excavation activities. Soils meeting UCLs were determined to be suitable for use as backfill. Those soils were used as backfill within the two drum areas. Blast rock from the construction of the retention pond and borrow soil from area adjacent to the excavations were also used as backfill.

Confirmation soil sample results obtained from the final excavation limits exhibited concentrations of OCSS-related constituents well below the MCP UCLs, and, in most cases, below the MCP S-3 soil standards. The successful completion of the RAM for Former Drum Areas A and B is documented in the RAM Status Report No. 1 (Geotechnical Engineers Inc. [GEI], 2000a) and the Drum Removal RAM Status Report No. 2 and Completion Statement (GEI, 2001).

Metal debris from the Buried Debris Area was disposed off-site as non-hazardous solid waste. The same soil segregation, stockpiling, and testing of excavated soils and the soils from the bottom and sidewalls of the excavations from the Buried Debris Area was conducted. All stockpiled soils met re-use criteria and were used as backfill. Forty confirmation samples were collected to verify that the MCP soil objectives were achieved. Confirmation soil sample results obtained from the final excavation limits exhibited concentrations of OCSS-related constituents below the MCP UCLs and the MCP S-3 soil standards. The successful completion of the RAM for the Buried Debris Area is documented in Construction-Related RAM Status Report No. 1 and Part 2 Construction-Related RAM Status Report No. 8 (GEI, 2000b and 2004). On March 29, 2005, the MassDEP approved the Part 2 RAM Status Report and the Construction-RAM Completion Statement related to this work.

After construction of the Slurry Wall, a layer of containment wall excavation spoils and calcium sulfate spoils (lined lagoon) mixed with cement was placed in the middle of the containment area.

During construction of the temporary cap, a layer of non-woven geotextile was covered with 6 inches of compacted sand and gravel and Tensar® geogrid. Sand and gravel from an off-site source was then placed over the geogrid and compacted to final grade. The polyethylene sheeting was installed at the surface.

The remediated drum areas and the Buried Debris Area represent a small fraction of the total extent of the Containment Area. For the remainder of the Containment Area, where no subsurface anomalies were identified, analytical data are available for numerous soil borings. The data set for subsurface samples (1-10 ft bgs) collected from soils within the Containment Area includes more than 100 data points for VOCs, SVOCs, pesticides, and chromium, lead, and cadmium and 19 or more data points for other metals/inorganics. Surface soils within the Containment Area were sampled as part of the OU1/OU2 RI and was found to pose no unacceptable risk to human health for trespassers and industrial-commercial workers. Deeper soils within the Containment Area do not pose an unacceptable risk to Human Health due to the recorded institutional restrictions that prohibit any deeper excavation activities (no exposure pathway present).

Additional detail of the RAM for Drum Area A and B and the Buried Debris Area is provided in **Appendix A** along other soil data.

1.4 Nature and Extent of Contamination

The nature and extent of contamination across OU1 and OU2 are discussed in detail in the OU1/OU2 RI Report (AMEC, 2015). The nature and extent of impact in groundwater, as well as DAPL and the effects of DAPL on groundwater conditions in the vicinity of the OCSS, have been evaluated in the Draft OU3 RI Report (Amec Foster Wheeler, 2018a). As discussed previously, additional site investigations and revisions to the Draft OU3 RI Report are being conducted on a parallel track with this IAFS. Therefore, this section summarizes information from the Final OU1/OU2 RI Report and the Draft OU3 RI Report as it relates to the interim actions evaluated in the IAFS.

This section also summarizes information about DAPL and the effects of DAPL on groundwater conditions in the vicinity of the OCSS as presented in the Focused Remedial Investigation Report (MACTEC, 2007), Final Data Gap Analysis and Additional Field Studies Work Plan (Amec Foster Wheeler, 2015a), Final RI Report for OU1 and OU2 (Amec Foster Wheeler, 2015b), and the Draft Focused RI Report for DAPL. The Draft Focused RI Report for DAPL was developed simultaneously with a Focused Feasibility Study (FFS) for DAPL as mandated by the USEPA's timeline schedule presented in their May 22, 2017 letter.

1.4.1 Plant B LNAPL

As stated above, the LNAPL at Plant B consists of a process oil co-located with other organic contaminants including BEHP, TMPs and NDPA. As presented in SASR No. 23 the latest monitoring results from October 2018 indicate that well GW-23, located adjacent to the northeast corner of Plant B, is the only well with any significant amount of LNAPL present. LNAPL was measured at 0.39 feet in GW-23 in October 2018, whereas the other wells in the vicinity of Plant B reported LNAPL measurements of non-detect or between 0.01 and 0.03 feet. Therefore, the residual LNAPL appears to be limited to an isolated area near the northeast corner of the Plant B building.

1.4.2 Dense Aqueous Phase Liquid

The definition of DAPL has been discussed at length in the Draft OU3 RI report. The physical appearance, density, and major constituents and associated concentrations in DAPL have been presented in Section 1.3.2.

The nature of DAPL is primarily associated with inorganics (various anions, cations, and ammonia as described above) and contains NDMA as well as low concentrations of other organics.

The metal / inorganic constituents detected in DAPL include, in order of decreasing concentration: sulfate; sodium; chloride; ammonia; chromium; iron; aluminum; and manganese. Organic compounds detected in DAPL include, in order of decreasing concentration: phenol; acetone; 2-hexanone; bromoform; 2-butanone methyl ethyl ketone; bis 2-Ethylhexyl phthalate (BEHP); toluene; trimethylpentenes; 4-bromophenyl-phenylether; naphthalene; benzoic acid; NDMA; and 2-nitrodiphenylamine. A detailed discussion of the chemistry of DAPL was provided in the Draft Focused DAPL RI Report (Amec Foster Wheeler, 2017a) and is also summarized in the Draft OU3 RI report. NDMA has been detected in DAPL, and the highest concentrations of NDMA detected at the Site occur in DAPL. Detected concentrations of NDMA in DAPL range from 120 to 64,000 ng/L.

DAPL present at the OCSS is a result of historic disposal practices that ceased around 1972, and DAPL is no longer being formed or released. The DAPL formed ex-situ as a result of acid process waste waters with high dissolved total solids content (i.e., higher density liquids) being released to unlined ponds on the Property including Lake Poly, the East and West Acid Pits, and the three Acid Pits south of the East and West Warehouses. Once formed, DAPL migrated vertically by gravity, penetrating overburden groundwater under the disposal pits and accumulating along the bedrock surface. During infiltration of these dense fluids through the water column, convective mixing with groundwater dispersed the site-related compounds within the local aquifer. DAPL then flowed by gravity along the bedrock surface, collecting in a series of cascading (progressively lower) bedrock depressions. These are referred to as DAPL pools. DAPL in pools becomes more concentrated vertically as; dissolved constituent concentrations and fluid density increase with depth. These properties of DAPL cause it to move by gravity rather than with the groundwater gradient, allowing it to accumulate and remain within bedrock depressions. DAPL has been identified in pools residing in bedrock depressions beneath the Olin Property (on-Property DAPL Pool), immediately west of the Olin Property (off-PWD DAPL Pool), and further to the west near Main Street (Main Street DAPL Pool). The elevations of the DAPL surface in these pools have remained consistent over the last decade. The areal extent of the three DAPL pools is shown on **Figure 1.3-1**.

1.4.3 OU3 Groundwater

Groundwater impacts are associated with the industrial process water disposal practices that led to the formation and migration of DAPL. These process waters were disposed of at former Lake Poly and other unlined impoundments including the East and West Acid pits as well as three smaller acid pits as discussed in the OU3 RI Report and in Section 1.4.7 below.

During initial movement of DAPL by gravity flow, extensive convective mixing with groundwater occurred, expanding the extent of dissolved constituents in groundwater. These dissolved constituents subsequently migrated advectively with groundwater. Once the DAPL migrated by gravity past the groundwater divide and into the Ipswich watershed, advective movement of dissolved constituents in groundwater advanced the extent of contamination farther down the Western Bedrock Valley (WBV) and out into the MMB aquifer. On the eastern and southern side of the groundwater divide, diffuse groundwater that developed from DAPL has migrated to the east along South Ditch and dissolved constituents have migrated off the property. The extent of off-Property migration to the east and southeast in the Aberjona watershed is limited compared to the extent of migration that occurred within the MMB aquifer in the Ipswich watershed.

Groundwater impacts in the MMB aquifer (Ipswich Watershed) are primarily deep, occurring in the deep overburden and underlying bedrock. Analytical results of samples collected from monitoring well GW-83D, which is partially screened in bedrock, indicate that DAPL potentially flowed over the Main Street bedrock saddle that bordered the Main Street DAPL pool and migrated to the bottom of the MMB aquifer along the WBV. As discussed in the OU3 RI report, the WBV under the MMB aquifer is heavily faulted, indicating that bedrock there could not support the existence of a stable bedrock DAPL pool. Indications are that bedrock below the WBV is heavily impacted with diffuse groundwater with a possible isolated area of DAPL around GW-83D.

Several of the wells with diffuse groundwater characteristics are screened across shallow bedrock within the core of the plume and other bedrock wells and bedrock wells surrounding the northern side of MMB (GW-103BR, GE-407BR, and GW-65BRD) are also impacted. Pumping of the Town wells historically caused large drawdowns that would have resulted in upward vertical movement of bedrock groundwater into the overlying deep overburden groundwater. This conclusion is supported by the following observations concerning the distribution of contaminants:

- Deep overburden wells with diffuse groundwater in the core of the plume in the WBV are partially screened in bedrock,
- MP-5 Port 3, screened in bedrock, contains diffuse groundwater,
- Monitoring well GW-83D, partially screened in bedrock, contains DAPL,
- Concentrations in GW-103D for ammonia, sulfate, chloride, and sodium were highest when the Chestnut Street MWSWs were operating, indicating contaminated groundwater was being pulled upward behind the municipal wells, and
- NDMA concentrations in GW-103BR declined substantially in the several year period following Town well shut-down, indicating impacted bedrock groundwater had been pulled upward in bedrock due to operation of the MWSWs.

Vertical groundwater gradients between deep overburden and bedrock are generally weak to neutral, though well pairs within the WBV indicate both weak downward and upward gradients may be present. The thin but persistent extent of the deep diffuse groundwater in the bottom of WBV may be the result of both diffusion from underlying bedrock groundwater with some vertical advective component and vertical movement of groundwater from bedrock to overburden when the Town wells were actively used.

Distribution of Contaminants of Concern

NDMA is a primary contributor to risk for hypothetical future scenarios involving potable use of groundwater. Being the most mobile anthropogenic contaminant, its extent is representative of the full extent of groundwater impact. The extent of shallow and deep overburden groundwater impact based on NDMA distribution is presented in **Figure 1.4-1** and **1.4-2** respectively. The extent of impact in bedrock groundwater is presented in **Figure 1.4-3**.

The core of the overburden groundwater plume in the Ipswich watershed is represented by the extent of diffuse groundwater in deep overburden wells. The core of the overburden plume in the Aberjona watershed is represented by the region of diffuse groundwater surrounding the DAPL pools and along the water course of South Ditch. The groundwater contained in the core of the Ipswich plume is within the Zone II area of contribution to the Town wells and would be a source of dissolved constituents affecting the Town wells if they were to be operated in the future. The extent of the groundwater impact in the Aberjona watershed lies under a highly industrialized setting without identified medium- or high-yield aquifers and is not a source of future potable groundwater, except for existing private wells near Cook Avenue which are defined as GW-1 under the MCP. The extent of groundwater impacts within the Aberjona watershed is interpreted to be stable based on data collected during the OU3 RI, however this interpretation will be re-evaluated with the data obtained from the current comprehensive groundwater sampling effort. Some downgradient migration of NDMA has occurred in the deep overburden groundwater and bedrock groundwater systems within the Ipswich watershed since shut-down of the Town wells.

The extent of bedrock impact mirrors that of the overburden due to the source of bedrock impact originating in overburden at the bedrock interface. The direction of bedrock groundwater flow also mirrors that of overburden; the two groundwater systems are connected, so though local and seasonal changes in the groundwater divide may occur.

The distribution figures for the other primary risk contributors related to the OCSS (arsenic, cobalt, iron and manganese) as presented in the Draft OU3 RI report are provided in **Appendix B**. The distributions of cobalt, iron and manganese in deep overburden groundwater are similar to one another and similar to NDMA. Iron, manganese and cobalt levels are elevated in DAPL and decrease two or more orders of magnitude from diffuse to overlying groundwater. While these metals are highest in DAPL and diffuse groundwater in the core of the Ipswich watershed plume, they remain at or above Regional Screening Levels (RSL) (for Hazard Index [HI] =1) in groundwater downgradient of the DAPL pools. The RSL for iron is 1,400 micrograms per liter (µg/L), for manganese 430 µg/L, and for cobalt 6 µg/L. Beyond the diffuse groundwater at GW-65D iron is detected between 35,000 and 40,000 µg/L; manganese is detected from 1,000 to 1,200 µg/L and cobalt was detected at 1.7 µg/L. In bedrock groundwater, the distribution of iron and manganese is also similar to that of NDMA. The distribution of cobalt in bedrock shows more pronounced attenuation and its downgradient extent is appreciably reduced in comparison. Iron, manganese, and cobalt exceed RSLs in one or several wells within the deep overburden plume's farthest downgradient extent. This is also true for iron and manganese in bedrock groundwater. These constituents are naturally occurring and with the MMB wetland area, both iron and manganese concentrations are elevated.

Arsenic in bedrock groundwater resources in New England has been the subject of many years of study by the United States Geological Survey (USGS). Bedrock protoliths of sedimentary and volcanic origin in eastern Massachusetts, seaboard New Hampshire and coastal Maine are known to contain comparatively high levels of arsenic, and it is not uncommon for private bedrock water supplies to have arsenic concentrations above the maximum contaminant level (MCL). The distribution of arsenic in groundwater at the OCSS is strongly influenced by the oxidation-reduction potential (ORP) of the groundwater. Arsenic is elevated in DAPL due to the low pH. Within the Aberjona watershed, elevated arsenic is associated with slightly to moderately reducing groundwater conditions (negative oxidation –reduction potential) in both shallow and deep overburden as well as bedrock. This results in elevated arsenic concentrations in shallow overburden groundwater near former Plant B and east of East Warehouse, where processing oil LNAPL was encountered during the OU1 RI investigation. Arsenic concentrations are also elevated in deep overburden groundwater near Plants C, the Plant C boiler room, and D, also generally downgradient of East Warehouse. Farther east, elevated arsenic is present in GW-80S/D/BR, which is impacted by high concentrations of chlorinated solvents (adjacent to Whitney Barrel Company) and unrelated to the OCSS.

Within the Ipswich watershed, the highest arsenic concentrations are associated with DAPL in the Main Street DAPL pool (260 µg/L) and with groundwater at the Spinazzola Trust landfill at MW-208D (110 µg/L) and MW-208BR (58 µg/L). Elevated arsenic also occurs within the diffuse groundwater in the core of the Ipswich plume and in bedrock underlying that corresponding portion of the WBV. Slightly down gradient in the Ipswich watershed, arsenic concentrations are below the MCL.

Based on the distribution of arsenic above MCLs, groundwater oxidation state appears to be a major contributor to mobilizing arsenic in groundwater. The most abundant source of arsenic is likely naturally-occurring arsenic bound to iron hydroxides in the aquifer matrix.

1.4.4 OU1 Slurry Wall/Containment Area

Investigations of soils in the Containment Area are summarized in Section 1.3.4. **Appendix A** includes a presentation and summary of the analytical data available for soil within the Containment Area. The documentation of testing of soils for waste characterization purposes and for determining if the objectives of the release abatement measures were met (confirmatory sampling in the excavations and sampling of stockpiled soils to determine if they met re-use criteria).

Subsequently, the BHHRA (AMEC, 2014) did not identify any soil areas with unacceptable direct exposure risks to human receptors (trespassers and outdoor workers), including surface soils within the Containment Area (10 surface soil samples). Please note that the current deed restriction does not allow disturbance of soil within the Containment Area except for grading and shaping to construct a permanent cap. The calculated cancer risks for the future outdoor worker and future trespasser were $5x10^{-6}$ and $2x10^{-6}$, respectively, which are within the USEPA acceptable risk range of $1x10^{-4}$ to $1x10^{-6}$. The corresponding non-cancer hazard indices were 0.05 and 0.02, respectively, which are below the CERCLA limit of 1.0. The BHHRA concluded that the Property, including the Containment Area, is suitable for industrial/commercial use.

There are no identified areas within the Containment Area or OU1 where soils are eroding or migrating from the Containment Area. Additionally, based on current groundwater quality data, soils within the Containment Area do not pose a threat to receptors due to leaching of potential contaminants to groundwater (the shallow groundwater within the containment structure is not more contaminated than the groundwater surrounding the containment structure). Alternative CA-3 in Section 3.3.4.3 evaluates soils as a stand-alone alternative.

Based on recommendations in the Final OU1/OU2 RI Report (AMEC, 2015) approved by the USEPA in July 2015 (USEPA, 2015), installation of a permanent cap over the Containment Area is required to replace the temporary cap, with the objective to continue to permanently minimize infiltration into the Containment Structure.

1.4.5 DAPL and Groundwater Interaction

The primary transfer of constituents from DAPL to overlying groundwater occurs via chemical diffusion. This diffusion results in the presence of a "Diffuse Layer," which is an approximately three- to five-foot layer of groundwater lying above the DAPL, and is defined by specific conductance between 3,000 and 20,600 µmhos/cm. The majority of initial dissolved phase contaminants in groundwater resulted from convective mixing during the initial, vertical migration of the DAPL while the facility was being operated. The current flux through the diffuse layer is likely small in comparison to those initial releases from convective mixing.

DAPL also interacts with groundwater contained in the fractured bedrock aquifer beneath the DAPL pools. Bedrock throughout the OCSS consists of highly deformed mylonites composed of meta-sediments and diorite intrusive bodies. Metamorphosed granitic rocks are present underlying upland areas on the western side of the MMB aquifer. The bedrock has a dominant fracture pattern, striking to the northeast with westerly dips, that is well cross-connected by joints and fractures oriented in other directions. Over much of the OCSS, the upper approximately 10 ft of bedrock is weathered and more transmissive. The extent of weathering increases within the granitic lithologies, which, where investigated, have been shown to be more highly deformed and fractured. The upper on-Property DAPL pool rests primarily on more competent siliceous bedrock with limited indication of weathering. Weathering near the Main Street bedrock saddle appears to be more common based on results of studies to delineate the Main Street bedrock saddle. DAPL penetration below the DAPL pools is arrested vertically within dead-end fractures and by mixing with underlying groundwater in the fractured bedrock forming extensive areas of diffuse groundwater below and surrounding the DAPL pools in bedrock. Based on groundwater sampling results from MP-4 and GW-202BR, diffuse groundwater is present in fractured bedrock to depths of approximately 100 ft below the DAPL pools and may extend considerably deeper.

DAPL is also present in fractured bedrock at monitoring wells GW-43D and GW-83D. As described in the Draft OU3 RI report (Amec Foster Wheeler, 2018a) and the Draft Focused DAPL RI Report (Amec Foster Wheeler, 2017a), several pronounced vertical faults near the GW-83D boring suggest the inability to support a distinct DAPL pool, despite material that exhibits DAPL characteristics being observed in the well. The boring log for GW-83D indicates this well is partially screened in bedrock. The extent or continuity of DAPL in weathered bedrock is unknown. Whether this material can be extracted by conventional wells is also unknown. While this material is clearly a source or potential source to the dissolved phase, including diffuse groundwater, the efficacy of removal is highly questionable since the weathered bedrock zone is likely not a sloping surface that would favor gravity-driven flow. Groundwater extraction at a location downgradient of GW-83D is an option to be considered for the management of migration and would address groundwater that might be impacted by DAPL in weathered bedrock in the general area of GW-83D and the western bedrock valley. Additional discussion with the USEPA is appropriate before deciding whether DAPL in weathered bedrock should be considered in source control efforts. It should be noted Olin has reason to postulate that matrix diffusion may play a significant part in the duration of an ultimate groundwater remedy for the Site, and that Olin and USEPA will cooperatively develop a method to assess the significance of matrix diffusion once a path forward is decided for source control.

When the DAPL pools were originally formed 50 to 60 years ago, and DAPL was actively moving through the overburden to its present location, a larger volume of diffuse material was also created by these more dynamic transport processes. Since DAPL is no longer being formed and its movement has long been arrested by the bedrock depressions it occupies, diffuse material is no longer being formed by convective mixing mechanisms. The primary mechanism for the continued presence of dissolved DAPL constituents in groundwater is replenishment by diffusion from DAPL and advective movement with groundwater. The DAPL itself is no longer mobile as a dense fluid; however, dissolved constituents originating from DAPL are mobile once they enter diffuse groundwater and groundwater.

1.4.6 OU3 Aquifers and Watersheds

OU3 groundwater consists of two distinct groundwater systems including both overburden and bedrock aquifers flowing within two different watersheds separated by a groundwater divide. An overburden groundwater divide is located west and north of the Olin Property, near the Main Street DAPL Pool. The position of the divide corresponds approximately with Eames Street, then south parallel to Main Street. The location of the divide is sensitive to relatively small changes in groundwater elevation. Gradients are generally flat in the area where the divide occurs. The divide moves seasonally in response to changing precipitation patterns, groundwater recharge, and groundwater elevation conditions.

North and west of the groundwater divide, groundwater flows in the Ipswich Watershed towards the MMB aquifer. South of the groundwater divide, groundwater flows and mixes with overlying groundwater in the Aberjona watershed and discharges to surface water in South Ditch.

Note, the BHHRA provided a detailed assessment of groundwater classification under the MCP. With the exception of current GW-1 areas related to private residential wells in the Aberjona watershed, there were no areas with potential for future use of groundwater within the OU3 boundary in the Aberjona watershed. Nonetheless, at USEPA's direction, the OU3 BHHRA (December 2018) did evaluate hypothetical future potable use of Aberjona watershed groundwater (both overburden and bedrock) within the core of the groundwater plumes underlying the 51 Eames Street property (as defined by the extent of OU3 impacts).

1.5 Contaminant Fate and Transport / Conceptual Site Model

For current conditions at OU1 and OU2, there are few complete migration pathways. There is no evidence of any erosional transport of impacted soils due to storm water runoff. Areas are well grassed and permanent erosion controls are in place. The volatiles (primarily TMPs) that have been reported in subsurface soils are not located at occupied structures, and therefore are not part of a complete vapor intrusion pathway.

The distribution of COCs in environmental media at OU1 and OU2 is consistent with the physical/chemical characteristics and fate and transport characteristics of those chemicals. In general, BEHP, chromium, and TMPs are not highly water soluble and have been retained in soils and sediments. Ammonia is highly water soluble and is therefore highly mobile, as its role in groundwater/surface water interaction. Although the TMPs are highly volatile, their location in subsurface soils is not associated with any current complete vapor intrusion pathway. However, their presence in the subsurface is indicative of a potential vapor intrusion pathway if buildings were constructed and occupied in the future.

Most of the OCSS chemicals of interest are persistent chemicals, with little or no biotic or abiotic degradation in the natural environment. NDMA in surface water is naturally degraded by ultraviolet light in sunlight.

The CSM for DAPL (contaminant sources, migration pathways, and transport) was discussed in detail in the Draft Focused DAPL RI Report (Amec Foster Wheeler, 2017) and in the Draft OU3 RI Report (Amec Foster Wheeler, 2018a).

Sources of contamination at the Property were related to former manufacturing operations and disposal practices. Currently, there are no leachable sources of contaminants in unsaturated soil that could result in the formation of a groundwater plume in overburden or bedrock. Former contaminant sources in unsaturated soils in OU1 (AMEC, 2015) have been investigated and addressed through response actions under the MCP. These sources and other potential sources of contamination are identified below:

- Former Lake Poly, East and West Pits, and the three Acid Pits. Each of these unlined pits received liquids from the manufacturing operation between at some time between 1953 and approximately 1970. The liquids contained sulfuric acid, sodium chloride, sodium sulfate, ammonium chloride, ammonium sulfate, chromium sulfate, and other constituents. The liquids included dense fluids that stratified according to density within the ponds and then penetrated the groundwater column below the ponds to the bedrock surface, becoming DAPL. The DAPL then moved by gravity along the bedrock surface to its current location in the DAPL pools. These former sources were addressed under the MCP such that only residual impacts have been identified through the USEPA-approved RI for OUs 1 and 2 (AMEC, 2015).
- The liquid disposal practices resulted in the formation of DAPL pools located below the groundwater table and within bedrock depressions. These include the Main Street DAPL pool and the Upper DAPL pool, which is divided into an on-Property and off-PWD portion. The on-Property portion is largely within the Containment Area and the off-Property portion lies between the Containment Area and Jewel Drive. The Main Street DAPL pool is farther to the northwest. The DAPL pools are depicted on **Figure 1.3-1**.

As summarized in the Draft OU3 RI Report, extensive investigations were completed at the liquid disposal areas, and soil removal actions were conducted under the MCP. Surface soils under the temporary cap were characterized under OU1 remedial investigations.

A release of BEHP, TMPs and an LNAPL processing oil occurred decades ago in the vicinity of Plant B. The release of LNAPL has been addressed by ongoing actions at Plant B. Groundwater capture and treatment at Plant B is incidental to the objective of containing and recovering LNAPL, with pumping of less than 10 gpm. No additional actions are warranted at Plant B.

1.5.1 Migration Pathways

As previously mentioned, most of the impacts/sources (e.g., former pits; Lake Poly) on-Property have been remediated. There is no longer a direct migration pathway from former source areas (disposal features) to current DAPL pools. DAPL is no longer being formed; DAPL formation stopped when operations stopped disposal of process liquids into Lake Poly and other unlined lagoons. The DAPL pools are physically stable, and DAPL is wholly contained within bedrock depressions and in weathered fractured bedrock. There is no indication that DAPL is currently or will, in the future, migrate within the overburden as a discrete dense liquid. The dissolved constituents are mobile in the context that they diffuse from DAPL to the Diffuse Layer and then may migrate via advection and dispersion within groundwater.

DAPL has also been documented in shallow weathered fractured bedrock within monitoring wells GW-83D and GW-43D. These areas do not represent DAPL pools. The occurrence of DAPL in weathered bedrock outside the DAPL pools appears to have been the result of transport processes that were ongoing when the DAPL pools were formed and is not related to ongoing transport from the DAPL pools themselves. In the absence of a sloped surface, DAPL will not move, since the driving force for DAPL movement is gravity.

The primary transport mechanism of DAPL constituents is through diffusion and advective transport in groundwater. Diffuse groundwater is also transported advectively with groundwater according to local gradients, with some component of gravity flow. The dissolved constituents are subject to sorption, diffusion into fine grained soil material, precipitation within the aquifer matrix (aluminum, iron, chromium oxides and oxy-hydroxides, and acid sulfate minerals), and attenuation through dispersion and dilution.

The soluble constituents in DAPL diffuse vertically and form a Diffuse Layer several feet thick above the DAPL. The Diffuse Layer is subject to further vertical mixing and advective transport with groundwater with subsequent attenuation of dissolved constituents through dispersion, precipitation reactions, and diffusion (from groundwater back into low permeability strata). The diffuse layer represents a geochemical gradient-driven continuum between the DAPL and overlying groundwater.

Groundwater/DAPL interaction also occurs within bedrock under the DAPL pools. An extensive region of diffuse groundwater is present in bedrock beneath the DAPL pools to unknown depths and under the MMB aquifer within the WBV. As discussed previously, this region of the OCSS, though largely inaccessible, is extensively faulted and fractured based on available data. The very long-term effects of matrix diffusion in bedrock are a substantial technical concern that renders the likelihood of restoration of groundwater technically infeasible.

Due to the deep nature of groundwater impacts and great thickness of the MMB aquifer, impacted groundwater does not affect surface water quality within the Ipswich watershed. Within the Aberjona watershed, there is substantial interaction between impacted groundwater along the entire length of South Ditch, and to a lesser extent within the off-PWD, which is the headwater to the South Ditch. The South Ditch is a gaining stream and is supported entirely by discharge of groundwater. Calculated 7Q10 flows are zero and in summer months it is not uncommon for the central portion of South Ditch to go dry. This occurs when the water table drops physically below the streambed. Shallow bedrock and overlying overburden groundwater are impacted along the entire length of South Ditch as evidenced by the distribution of diffuse groundwater that surrounds the entire surface water body. The primary COCs affecting South Ditch surface water from an ecological risk perspective are ammonia and chromium. Other constituents encountered in DAPL and diffuse groundwater are also present but do not present ecological risk.

1.5.2 Receptors

Based on existing conditions, groundwater use restrictions, and the nature of DAPL (color, odor, taste, acidity), it is considered extremely unlikely that exposure to DAPL is a realistic scenario. Consequently, there is no current or foreseeable receptor for DAPL exposure. The BHHRA concluded that the calculated cancer risk for the hypothetical future potable use exposure scenario is above the upper end of the NCP and USEPA cancer risk range, the calculated non-cancer HI is above the CERCLA limit of 1, and the estimated blood lead levels for a child are below the USEPA target blood lead level of 10 µg/dL and the Center for Disease Control "reference level" of 5 µg/dL for hypothetical potable use of DAPL residual waste material. The BHHRA also provided the following uncertainty regarding the hypothetical potable use of DAPL residual waste material. Although potable use of DAPL has been evaluated as a hypothetical scenario, DAPL is not groundwater, but rather a waste material associated with past plant operations. The pumping and long-term ingestion of DAPL is considered an extraordinarily improbable scenario. The DAPL is green/black in color, which would be a signal to any responsible person that it is not suitable for drinking. In addition, the DAPL has low pH (well below the Secondary MCL of 6.5-8.5) and high dissolved solids (orders of magnitude above the Secondary MCL of 500 mg/L) including sulfate and chloride at concentrations orders of magnitude above the Secondary MCL of 250 mg/L for both, which would result in unpalatable taste.

A BHHRA has been completed and identified a hypothetical future risk for potable use of groundwater from the core of the plume within the Ipswich watershed. This groundwater is within the zone of influence of the former Town MWSWs. The primary risk contributors include NDMA, arsenic, cobalt, iron, and manganese.

1.5.3 Environmental Fate and Transport

The focus of this IAFS is to: 1) address DAPL in each of the three DAPL pools where sufficient characterization exists to identify effective approaches to reduce the volume of DAPL acting as a source of dissolved phase constituents to groundwater; 2) control downgradient migration of the groundwater plume within the MMB aquifer in the Ipswich watershed, and; 3) enhance recovery of mobile LNAPL at Plant B which acts as an ongoing source to groundwater; and 4) take actions toward hydraulic isolation of the Containment Area. These actions will also help control exposure of current and future receptors to contaminants in the environment under reasonably foreseeable scenarios. Therefore, the following summary of environmental fate and transport considers the physical fate and transport of both DAPL and dissolved constituents associated with DAPL that are primary risk contributors.

<u>DAPL Pools</u>

The elevation of the DAPL interfaces in the DAPL pools was documented by induction logging and multilevel piezometer sampling through 2005 and these elevations appear to be consistent over time within measurement accuracy. The investigations conducted to define the DAPL pools also defined (to the extent possible given geologic variability) the elevations of the outlets represented by the low spot in the bedrock saddles. These low spots are where DAPL is presumed to have overflown into the next bedrock pool. The elevations of the DAPL pools are, within measurable certainty, close to the interpreted elevations of the saddles that contain them.

The location of the DAPL pools are well established and known to an extent that permits an evaluation in this IAFS. Although potable use of DAPL has been evaluated as a hypothetical scenario in the BHHRA, DAPL is not groundwater, but rather a waste material associated with past plant operations. The pumping and long-term ingestion of DAPL as a drinking water scenario is considered an extraordinarily improbable scenario for many reasons discussed in other documents.

Dissolved Constituents

The dissolved constituents from the Property that are major risk contributors for potable use of groundwater within the core of the Ipswich plume include NDMA, cobalt, arsenic, iron, and manganese.

The dissolved constituents that are major risk contributors within the core of the Ipswich plume include several other constituents that are not associated with releases from the OCSS: 1,2-DCA, benzene, cis-1,2-DCE, naphthalene, TCE and VC. The Butters Row Treatment Plant was specifically designed to remove TCE and other VOCs encountered in the town MWSWs. The historical sources of these VOCs have not been investigated under OU3. Their persistence in the aquifer will be dependent on the sources and potential for natural attenuation by biological degradation in groundwater.

NDMA will not degrade biologically, is highly soluble, has a low K_{oc}, and will not readily absorb to organic carbon or reactive mineral surfaces in the aquifer. Its primary mechanism of attenuation is diffusion, advection, and dispersion in groundwater. NDMA is susceptible to oxidation by ultraviolet (UV) light at wavelengths found in natural sunlight. The published half-life for NDMA in clear water is on the order of seven minutes; therefore, it will degrade efficiently in surface water depending on the clarity of the water and its light transmitting properties. NDMA will attenuate by diffusion, advection and dispersion; sorption and degradation are not significant mechanisms.

The Draft OU3 RI evaluated metals, including the transitional metal arsenic, from a geochemical perspective to determine if the elevated levels of these metals are due to anthropogenic inputs or whether they were present naturally and mobilized due to geochemical changes associated with DAPL. With the exception of chromium, the other metal COPCs (arsenic, antimony, cobalt, nickel, iron and manganese) are naturally occurring and appear to have been mobilized by the low pH of DAPL. Arsenic is also mobilized where groundwater pH is reduced due to other environmental conditions (i.e., landfills, presence of volatile organic compounds).

Aluminum concentrations are elevated within the DAPL pools up to five orders of magnitude higher than at groundwater locations where NDMA is not detected. This is evidence of geochemical alteration of clays and mobilization of metals. Concentrations of aluminum dissipate rapidly in groundwater beyond the DAPL pools as more neutral pH groundwater is encountered and aluminum oxides as gibbsite quickly reprecipitates on the aquifer matrix. Ambient aluminum concentrations appear to range from non-detect to 0.25 mg/L.

Cobalt and aluminum concentrations are strongly correlated, particularly at higher concentrations. The distribution of cobalt is similar to that of aluminum. Cobalt is more persistent downgradient than aluminum indicating re-sorption to the aquifer matrix is a slower process. Cobalt remains slightly elevated around the plume core within and immediately surrounding the diffuse groundwater within MMB aquifer in the WBV. Cobalt attenuates down gradient. These conditions indicate natural attenuation of metals is occurring downgradient.

Manganese and iron have similar geochemical behaviors, though they have different valence states and properties. Manganese becomes more soluble with decreasing pH so in areas of low pH manganese concentrations increase. Iron changes from an insoluble (ferric) to a soluble (ferrous) form under reducing conditions and lower pH. Thus, as pH declines to acidic conditions or when oxygen is consumed and ORP becomes negative, dissolved iron concentrations increase. Metals complexed with ferric iron, notably arsenic, are released when iron is converted to ferrous iron. Metals also partition to manganese hydroxides, and as manganese solubilizes with decreasing pH, those metals are also released. Metals released in this manner will re-sorb or re-complex and attenuate as groundwater moves down gradient and geochemical conditions return to those of ambient groundwater.

The distribution of chromium, which has a large anthropogenic component in DAPL, attenuates rapidly in groundwater downgradient from the DAPL pools due to precipitation with sulfate and with aluminum hydroxides on ferric iron nucleation sites on the aquifer matrix. Downgradient from the core of the plume, chromium is below detection limits with few exceptions. Other metals including cobalt, arsenic, iron and manganese will attenuate geochemically downgradient under normal aquifer conditions.

The other major mechanism affecting the long-term fate and transport of NDMA and other constituents is matrix diffusion particularly where bedrock is impacted by DAPL and diffuse groundwater. This topic requires additional study and is not further discussed here.

1.6 Baseline Risk Assessments

The BHHRA included in the USEPA-approved OU1/OU2 RI Report (AMEC, 2015) and the Draft BHHRA for OU3 (Wood, 2018) submitted to USEPA provided health risk information relevant to the interim actions identified and recommended in this IAFS. The BHHRA for the OU1/OU2 RI Report evaluated risks associated with surface soil currently located beneath the temporary cap at the Containment Area. The December 2018 Draft OU3 BHHRA was reviewed by USEPA and it evaluated risks for current, future, and hypothetical exposures to groundwater (potable use and non-potable irrigation use) in the Ipswich Watershed as well as hypothetical long-term potable use of DAPL. The results/conclusions of these BHHRAs concerning media and receptor scenarios that are relevant to the interim actions that are the focus of the IAFS are summarized below.

1.6.1 OU1/OU2 BHHRA

The BHHRA for OU1 and OU2 (AMEC, 2015) was approved by USEPA as part of the Final OU1/OU2 RI Report. It evaluated hypothetical potential trespasser and outdoor worker exposures and risks associated with surface soil (0-1 ft bgs) beneath the current temporary cap at the Containment Area. It should be noted that the current deed restriction does not allow disturbance of soil within the Containment Area except for grading and shaping to construct a permanent cap. The calculated cancer risks for the future outdoor worker and future trespasser were $5x10^{-6}$ and $2x10^{-6}$, respectively, which are which are within the USEPA acceptable risk range of $1x10^{-4}$ to $1x10^{-6}$. The corresponding non-cancer hazard indices were 0.05 and 0.02, respectively, which are well below the CERCLA limit of 1.0. The BHHRA concluded that the Property, including the Containment Area, is suitable for industrial/commercial use. The BHHRA did not evaluate potential exposure to deeper soils within the Containment Area because the deed restriction would not allow activities that would result in such exposure. Note, the 2015 OU1/OU2 RI report, which included OU1/OU2 BHHRA was approved by USEPA in July, 2015.

1.6.2 Draft BHHRA OU3

BHHRA was completed and included as Appendix I to the Draft OU3 RI Report (Amec Foster Wheeler, 2018a) in March 2018. Based on comments from USEPA, a revised BHHRA for OU3 was completed and submitted to the USEPA in December 2018 (Wood Environment & Infrastructure, Inc., 2018). The conclusions of the OU3 BHHRA for relevant media and receptor scenarios are summarized in the following paragraphs.

1.6.2.1. Current Exposure Scenarios

- Calculated cancer risks for the current exposure scenarios are below the upper end of the NCP and USEPA cancer risk range and the calculated non-cancer HIs meet the CERCLA limit of 1 for:
  - Thirteen residential wells within the extent of NDMA groundwater impact;
  - Millbrook Country Day School Inc. public water supply; and
  - One residential well used for non-potable purposes (irrigation).
- Three residential wells have a calculated cancer risk at or above the upper end of the NCP and USEPA cancer risk range if hexavalent chromium is included as a COPC. If these hexavalent chromium detections are treated as false positives (consistent with the RI Report) and are not included as COPCs, then calculated risks are below the upper end of the NCP and USEPA cancer risk range. It is our opinion that the reported hexavalent

chromium concentrations are false positives and therefore, the cancer risk for these three residential wells are below the upper end of the NCP and USEPA cancer risk range.

1.6.2.2. Future Exposure Scenarios

- Calculated cancer risks for the potential future exposure scenarios are below the upper end of the NCP and USEPA cancer risk range and the calculated non-cancer HIs meet the CERCLA limit of 1 for:
  - Future irrigation use of two inactive industrial/commercial wells at One Jewel Drive;
  - Future Construction Worker exposure to shallow groundwater – on-Property (excluding Plant B Area);
  - Future Construction Worker exposure to shallow groundwater – off-Property;
- Calculated cancer risks for the future exposure scenarios are above the upper end of the NCP and USEPA cancer risk range and the calculated non-cancer HIs are above the CERCLA limit of 1 for:
  - Future potable use of groundwater from the Ipswich Watershed overburden aquifer (Reasonable Maximum Exposure (RME) scenario) – potential future installation of private or public wells or resumption of operation of currently inactive MWSWs;
  - Future potable use of groundwater from the Ipswich Watershed bedrock aquifer (RME scenario) – potential future installation of private or public wells or resumption of operation of currently inactive MWSWs;
- Calculated cancer risks for the future exposure scenario are below the upper end of the NCP and USEPA cancer risk range and the calculated non-cancer HI is above the CERCLA limit of 1 for:
  - Future Construction Worker exposure to shallow groundwater – on Property (Plant B Area). Note: a groundwater remedial system is currently operating in this area of the Property.

1.6.2.3. Hypothetical Future Exposure Scenarios

- Calculated cancer risks for the hypothetical future exposure scenarios are above the upper end of the NCP and USEPA cancer risk range and the calculated non-cancer HIs are above the CERCLA limit of 1 for:

- Hypothetical future potable use of groundwater from the Aberjona Watershed overburden aquifer (RME scenario); and
- Hypothetical future potable use of groundwater from the Aberjona Watershed bedrock aquifer (RME scenario).

- Calculated cancer risk for the hypothetical future exposure scenario is above the upper end of the NCP and USEPA cancer risk range, the calculated non-cancer HI is above the CERCLA limit of 1, and the estimated blood lead levels for a child are below the USEPA target blood lead level of 10 µg/dL and the CDC "reference level" of 5 µg/dL for:
  - Hypothetical potable use of DAPL residual waste material.

1.7 Site Characterization Summary

The nature and extent of contamination for OU1/OU2 soil, surface water, and sediment has been well characterized and defined. The data are adequate to support risk characterization and risk management decisions. The conclusions relevant to this IAFS of the OU1/OU2 RI Report are provided below:

- The human health risk assessment indicates the Property overall is suitable for industrial/commercial use.

Additionally, the current temporary Containment Area cap was installed to reduce the influx of precipitation and storm water into the Containment Area as part of the 2000/2001 RAM, which has been maintained over the years and was not designed or intended as a permanent cover or cap. Based on recommendations in the Final OU1/OU2 RI Report (AMEC, 2015) approved by the USEPA in July 2015 (USEPA, 2015), remedial alternatives evaluated in the OU1/OU2 FS should include installation of a permanent cap over the OU1 Containment Area, the objective of which is to continue to permanently minimize infiltration into the Containment Structure. Additional site investigations are planned for the vicinity of the Containment Area. Capping alternatives as well as soil removal for the Containment Area are evaluated in this IAFS.

The nature and extent of the OU3 groundwater and the DAPL pools have been adequately delineated and documented in the OU3 RI Report to support this IAFS. DAPL as a separate phase is not migrating. There is no evidence to suggest NDMA is forming in DAPL or diffuse groundwater. The exact mechanism of formation of NDMA remains unknown, though it is clearly present in DAPL and diffuse groundwater.

A BHHRA has been performed based on analysis of potential future groundwater source areas. The BHHRA also evaluated current hypothetical exposure to NDMA by ingestion, dermal contact, and inhalation in residential settings where impacted groundwater is the source of potable water. The BHHRA concluded the following:

- Potable use of groundwater does not pose an unacceptable risk at the residential wells evaluated.
- Potable use of groundwater from the core of the plume in the Ipswich watershed would result in lifetime cancer risks of greater than 1x10-4 and an HI greater than 1. Primary contributors to risk include NDMA, arsenic, cobalt, iron, and manganese.
- Other risk contributors not associated with releases from the OCSS include 1,2-1,2-DCA, benzene, cis-1,2-DCE, naphthalene, TCE and VC. These constituents are not considered site-related, as there was no reported use of chlorinated solvents at the OCSS. Since the volatile organic compounds identified within the Ipswich plume do not originate from the OCSS, consideration of the sources of those contaminants is not within the scope of the RI/FS.
- Although there is no current exposure to DAPL and exposure under any circumstances is considered improbable, long-term ingestion of DAPL would present cancer risk and noncancer hazard above CERCLA limits. However, given the nature of DAPL (color, odor, taste, acidity), it is considered extremely unlikely that exposure to DAPL is a realistic scenario.

Additional conclusions from the OU3 RI report include:

- Bedrock underlying the DAPL pools and bedrock within the WBV under the region of diffuse groundwater have had long term impacts from high concentrations of NDMA. These areas are believed to contain a mass retained by matrix diffusion that is significant enough to render treatment of bedrock groundwater by extraction and treatment technically infeasible.
- Future use of the Town wells will induce upward vertical gradients from underlying bedrock groundwater to deep overburden groundwater and therefore restoration of the MMB overburden aquifer to potable quality is not feasible in the foreseeable future.
- Restoring the Town wells to productive use is feasible if additional treatment trains are added to address other constituents such as NDMA, metals, and nitrate, the latter of which affects the residual chlorine levels in treated groundwater.
- DAPL pilot extraction testing has shown DAPL extraction is feasible within the DAPL pools where bedrock slopes to a low point that can be used to facilitate capture of DAPL by gravity drainage and removal by pumping. DAPL not constrained by a sloping bedrock

depression and not within a constrained pool will not flow by gravity toward an extraction well.

- DAPL extraction will not remove all DAPL. As extraction progresses, DAPL naturally becomes less dense and less concentrated as the top of the pool is drawn downward. This will limit the effectiveness of DAPL extraction by gravity drainage in the long run.
- Extraction of DAPL will not result in attainment of groundwater restoration goals within a meaningful time frame.

Based on the results of the Draft OU3 RI and the associated BHHRA, a feasibility study was recommended that addresses the future potable use of groundwater within the MMB aquifer where the core of the overburden and bedrock plume resides. Although there is no reasonably foreseeable exposure to DAPL, the FS should address migration of dissolved constituents in the Ipswich watershed associated with DAPL and DAPL as an ongoing source of those constituents.

Subsequent to submittal of the Draft OU3 RI Report and receipt of USEPA review comments, a meeting was held between the USEPA and Olin on December 10, 2018. As a result of this meeting and further discussions, Olin agreed to prepare this IAFS to evaluate interim action alternatives to: (1) enhance LNAPL recovery at Plant B; (2) Reduce, to the extent practicable, volume of DAPL and mass of constituents in the DAPL from the On-Property, Off-PWD, and Main Street DAPL Pools; (3) manage downgradient migration of higher-concentration groundwater in the Ipswich Watershed: and (4) take actions towards hydraulic isolation of the Containment Area. The IAFS will also evaluate remedial alternatives to enhance the recovery of LNAPL in the vicinity of Plant B.

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section identifies and screens remedial technologies using the process outlined in the NCP and USEPA RI/FS guidance (USEPA, 1988b). This section discusses the interim action objectives, identifies appropriate general response actions, and identifies and screens remedial alternatives. The identification and screening of technologies incorporates a streamlined approach to identify most appropriate technologies and alternatives to meet the objectives of the interim actions. The simplicity of this approach is consistent with the intent of interim actions versus the intent of final remedial actions. In some cases, the interim actions could become final remedies or important components of the same.

2.1 Interim Action Objectives

The interim action objectives have been identified through discussions between USEPA and Olin. They are identified in Section 1.0 and are repeated here to frame the remainder of the identification and screening of remedial technologies.

The interim action objectives are, simply stated, as follows.

- Enhance the recovery of Light Non-Aqueous Phase Liquid (LNAPL) from the subsurface at the currently operating Plant B groundwater recovery and treatment system.
- Reduce, to the extent practicable, volume of DAPL and mass of constituents in the DAPL pools that represent a source of constituents to groundwater and surface water.
- Manage downgradient migration of higher-concentration of NDMA in groundwater within the Ipswich Watershed.
- Take actions towards hydraulic isolation of the Containment Area and to protect against potential exposure to Containment Area soils.

In the text below, additional evaluation is added to these interim action objectives to support the identification and screening of appropriate technologies.

The process begins with the identification ARARs, followed by development of IAOs. Chemical-specific numerical cleanup goals are typically then established, but in context of this evaluation. Estimates are made of the areas and volumes of media that exceed numerical cleanup goals. Potential cleanup technologies are then identified and screened to produce a list of suitable technologies that can be assembled into remedial alternatives capable of mitigating actual or potential risks at the OCSS.

As discussed in various subsections throughout Section 1.0, this IAFS is being prepared to evaluate remedial alternatives to enhance LNAPL recovery at Plant B, remove DAPL from three DAPL pools, manage downgradient migration of higher-concentration of NDMA in groundwater in the Ipswich Watershed, and take actions toward hydraulic isolation of the Containment Area and maintain inaccessibility of soils in that area. For these interim actions, not all of the components of a typical FS are important or applicable and therefore are not discussed in detail in this IAFS. With respect to ARARs for these interim actions, the focus is on the ARARs that are specifically related to the proposed actions as opposed to the ARARs that apply to specific environmental media. For example, with respect to removal of DAPL as a source material, the purpose is to reduce volume and mass and there is not a specific ARAR related to a numerical cleanup goal (there are none for DAPL), so the most relevant ARARs are those that address the handling, transport, and off-site treatment and disposal of the extracted material. The enhanced LNAPL recovery is a similar situation, with no numerical cleanup requirements. The numerical cleanup requirements for the management of migration in Ipswich Watershed groundwater are related to the ultimate disposition of the groundwater (e.g., potential discharge permit requirements for groundwater discharged to surface water or drinking water ARARs and risk-based criteria if the extracted groundwater is treated for potable use) rather than achieving specific numerical cleanup levels in the ambient groundwater.

2.1.1 Applicable or Relevant and Appropriate Requirements (ARARs)

CERCLA and the NCP require that on-site Superfund remedial actions must attain federal standards, requirements, limitations, or more stringent state standards determined to be legally applicable or relevant and appropriate to the circumstances at a given site. ARARs are federal environmental and state environmental and facility siting requirements used to: (1) evaluate the appropriate extent of site cleanup; (2) define and formulate remedial action alternatives; and (3) govern implementation and operation of the selected action. Inherent in the interpretation of ARARs is the assumption that protection of human health and the environment is ensured.

To properly consider ARARs and to clarify their function in the remedy selection process, the NCP defines two ARAR components: (1) applicable requirements; and (2) relevant and appropriate requirements. These definitions are discussed in the following paragraphs.

Applicable Requirements. Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site (40 CFR 300.400(g)). To be applicable, a requirement must directly and fully address a CERCLA activity.

Relevant and Appropriate Requirements. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the site that their use is well-suited to the particular site (40 CFR 300.400(g)(2)). ARARs are divided into the three categories described in the following paragraphs.

Location-specific ARARs set restrictions upon the concentration of hazardous substances or the conduct of activities solely because they are in special locations. In determining the use of location-specific ARARs for selected remedial actions at CERCLA sites, one must investigate the jurisdictional prerequisites of each of the regulations. Basic definitions and exemptions must be analyzed on a site-specific basis to confirm the correct application of the requirements.

Chemical specific ARARs are usually health- or risk-based numerical values or methodologies that establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the environment (USEPA, 1988a). They govern the extent of site remediation by providing either actual cleanup levels, or the basis for calculating such levels. For example, groundwater MCLs provide federally enforceable standards used in development of cleanup goals for contaminated groundwater. If treated groundwater is discharged to a surface water body, the treated effluent would need to meet National Recommended Water Quality Criteria. Chemical-specific ARARs may also be used to indicate acceptable levels of discharge in determining treatment and disposal requirements, and to assess the effectiveness of future remedial alternatives. There are no chemical-specific ARARs associated with DAPL.

Action-specific ARARs are usually technology- or activity-based requirements or limitations on remedial actions taken (USEPA, 1988a). Selection of a particular response action at a site will invoke the appropriate action-specific ARARs that may specify particular performance standards or technologies, as well as specific environmental levels for discharged or residual chemicals.

Many regulations can fall into more than one category. For example, many location-specific ARARs are also action-specific because they are triggered if response activities affect site features. Likewise, many chemical-specific ARARs are also location-specific.

The Occupational Safety and Health Administration (OSHA) has promulgated standards for protection of workers who may be exposed to hazardous substances at Resource Conservation and Recovery Act (RCRA) or CERCLA sites. USEPA requires compliance with the OSHA standards in the NCP, not through the ARAR process. Therefore, the OSHA standards are not considered as

ARARs. Although the requirements, standards, and regulations of OSHA are not ARARs, they will be complied with during response activities.

Preliminary Identification of ARARs. The location-, chemical-, and potential action-specific ARARs identified in support of this IAFS are presented herein by media. **Tables 2.1-1 and 2.1-2** present location- and potential action-specific ARARs for LNAPL Alternatives. **Tables 2.1-3 and 2.1-4** present location- and potential action-specific ARARs for DAPL Alternatives. **Tables 2.1-5 through 2.1-7** present location-, chemical-, and potential action-specific ARARs for Groundwater Alternatives. **Tables 2.1-8 through 2.1-10** present location-, chemical-, and potential action-specific ARARs for the Containment Area Alternatives. Columns at the right of the ARAR tables denote applicability to each of the identified alternatives.

In summary, location-specific ARARs include federal and state regulations related to wetlands and surface waters. Chemical-specific ARARs include federal and state MCLs. Action-specific ARARs include federal and state regulations relative to: RCRA identification and listing of hazardous waste; standards applicable to generators of hazardous waste; and RCRA requirements for storage and disposal of hazardous waste.

2.1.2 Chemicals of Concern

For future potable use of groundwater, those chemicals with exposure point concentrations greater than applicable drinking water standards are identified as ARARs-based chemicals of concern (COCs). Arsenic is the primary ARARs based COC within the core of the plume in the Ipswich Watershed. The term primary is used to identify the COCs that contribute the largest amount of risk (risk drivers). Other infrequently detected constituents contribute much less risk (e.g., chlorinated solvents).

The primary human health risk-based COCs were identified for future potable use of Ipswich Watershed groundwater in the OU3 BHHRA (Wood, December 2018) and included

NDMA, cobalt, iron, manganese, and arsenic. The other OU3 Contaminants of Interest (COIs) that are important to consider for groundwater treatment include:

- Aluminum
- Ammonia
- Calcium
- Chloride
- Chromium

- Sodium
- Sulfate
- Nitrate

The ARARs-based and human health risk-based COCs are considered primarily for groundwater treatment.

2.1.3 Development of Preliminary Remediation Goals

Preliminary remediation goals (PRGs) are medium-specific concentrations used during analysis and selection of interim action alternatives. PRGs should comply with ARARs and result in residual risks consistent with NCP requirements for protection of human health and the environment. Therefore, there are both ARAR-based PRGs and risk-based PRGs. Eventually, PRGs may be modified and/or potentially become the basis for final remediation levels for the selected remedy. ARARs-based and risk-based PRGs are not relevant for the enhancement of LNAPL recovery nor for reduction of volume or mass of DAPL nor for capping of the containment area. PRGs are relevant to the management of migration alternatives most notably if the alternatives involve either use of the groundwater for potable purposes or if the groundwater is discharged to surface water. It should be noted that PRGs would not be applied as to ambient groundwater for the purposes of identifying concentration goals for interim actions.

ARAR-based PRGs for the OCSS include MCLs for groundwater. Risk-based PRGs were developed and presented in Table 5.3-2 of the OU3 BHHRA. The risk-based PRG ranges for COPCs are listed below.

- NDMA: 0.016 to 0.16 µg/L (HQ = 0.1, 1.0) and 0.00047 µg/L to 0.047 µg/L (cancer risk of $1x10^{-6}$ and $1x10^{-4}$)
- Cobalt: 0.6 to 6 µg/L (HQ = 0.1, 1.0)
- Iron: 1,400 to 14,000 µg/L (HQ = 0.1, 1.0)
- Manganese: 43 to 430 µg/L (HQ = 0.1, 1.0)
- Arsenic: 0.6 to 6 µg/L (HQ = 0.1, 1.0) and 0.052 µg/L to 5.2 µg/L (cancer risk of $1x10^{-6}$ and $1x10^{-4}$)

2.1.4 Volumes and Areas of Media to be Addressed

This subsection presents the most recent estimated volumes of media, as applicable, associated with LNAPL near Plant B, and the DAPL pools. Since the objective for groundwater is containment of downgradient migration, not restoration, .an estimate of the volume of impacted groundwater is not needed.

The extent of the spill volume under the Plant B foundation is unknown. Therefore, for evaluation purposes it has been assumed LNAPL recovery at current rates would continue for approximately 10 more years.

The bedrock surface contours of the DAPL pools were interpolated using 3-D analytical tools within Surfer™ and ESRI Arc-GIS™ to develop a point-based volume (in cubic feet) of the region between the bedrock surface and the DAPL pool elevation. This volume represents the volume of DAPL within the porous media which is assumed to have a porosity of 23 percent for poorly graded sands and gravelly sands and 25 percent for silty sands. When adjusted for porosity and converted to gallons the estimated volumes are approximately:

- on-Property DAPL Pool 190,000 gallons
- off-PWD DAPL Pool 1,000,000 gallons
- Main Street DAPL Pool 13,000,000 gallons

These volumes reflect the recent depth to bedrock data for the Main Street DAPL Pool and the remaining volume in the off-PWD DAPL pool, which reflects continued efforts to extract DAPL by pumping since the end of the DAPL.

2.2 General Response Actions

General response actions are categories of remedial actions that may be used to satisfy IAOs by either reducing the contaminant concentration in each medium below the PRG or by preventing receptor exposure to the contaminated medium. General response actions describe categories of remedial actions that may be employed to satisfy IAOs and provide the basis for identifying specific remedial technologies.

Potential general response actions for LNAPL are:

- No Action
- Institutional Controls
- Treatment
- Removal

- Disposal

Potential general response actions for DAPL are:

- No Action
- Institutional Controls
- Containment
- Treatment
- Removal
- Disposal

Potential general response actions for groundwater are:

- No Action
- Institutional Controls
- Natural Recovery
- Treatment
- Containment/Removal
- Disposal

Potential general response actions for the Containment Area soils are:

- No Action
- Institutional Controls
- Containment
- Removal
- Disposal

2.3 Identification and Screening of Technologies and Process Options

This section identifies and screens remedial technologies for those impacts identified as ongoing sources (LNAPL near Plant B, the DAPL pools, groundwater in the Ipswich watershed, and the Containment Area) using the process outlined in the NCP and USEPA RI/FS guidance (USEPA, 1988b and 1990). Technologies with potential to attain the IAOs established in Subsection 2.1

and corresponding to the categories of general response actions described in Subsection 2.2 are identified. Demonstrated performance of each technology for site contaminants and conditions is considered during technology identification. The result is a list of potential remedial technologies that are then screened based on their applicability to site- and waste-limiting characteristics. The purpose of the screening is to produce a list of suitable technologies that can then be assembled into remedial alternatives capable of mitigating actual or potential risks at the site.

2.3.1 Identification and Screening of Technologies

Categories of remedial technologies and specific process options were identified based on a review of literature, vendor information, performance data, and experience in developing other FSs under CERCLA. Process options with potential to attain the remedial action objectives were retained during the screening.

The technology screening process reduces the number of potentially applicable technologies and process options by evaluating factors that may influence process-option effectiveness and implementability and is consistent with CERCLA guidance for performing an FS (USEPA, 1988b).

The screening process assesses each technology or process option for its effectiveness and implementability with regard to site-specific conditions, known and suspected contaminants, and affected environmental media. The effectiveness evaluation focuses on: (1) whether the technology is capable of handling the estimated areas or volumes of media and meeting the contaminant reduction goals identified in the IAOs; (2) the effectiveness of the technology in protecting human health and the environment during the construction and implementation phase; and (3) how proven and reliable the technology is with respect to contaminants and conditions at the site. Implementability encompasses both the technical and administrative feasibility of implementing a technology.

Waste-limiting characteristics primarily establish the effectiveness and performance of a technology; site-limiting characteristics affect implementability of a technology. Waste-limiting characteristics consider the suitability of a technology based on contaminant types, individual compound properties (e.g., volatility, solubility, specific gravity, adsorption potential, and biodegradability), and interactions that may occur between mixtures of compounds (e.g., chemical reactions or increased solubility). Site-limiting characteristics consider the effect of site-specific physical features on the implementability of a technology, including topography, buildings, underground utilities, available space, and proximity to sensitive operations. Technology screening based on waste- and site-limiting characteristics serves a two-fold purpose of screening out technologies whose applicability is limited by site-specific waste or site considerations, while retaining as many potentially applicable technologies as possible. At this stage in the process, relative costs are considered to eliminate technologies that are substantially less cost-effective.

2.3.2 Evaluation of Technologies and Selection of Representative Technologies

2.3.2.1. Enhancement of LNAPL Recovery

Table 2.3-1 presents the technology screening for LNAPL. Technologies and process options judged ineffective or not implementable were not retained. The retained technologies and process options are those considered most suitable for remediation of DAPL at the OCSS. The retained technologies/process options may be used alone or integrated with other technologies to develop remedial alternatives.

The following paragraphs summarize the results of technology screening for LNAPL near Plant B:

Institutional Controls. Technologies identified that may be used as components of remedial alternatives to provide institutional controls are deed covenants and environmental monitoring.

Treatment. Biodegradation and air sparging/soil vapor extraction are not retained because they have previously proven ineffective or been used to diminishing effectiveness on LNAPL near Plant B. In-situ chemical oxidation, co-solvent flushing, steam/hot air injection, and radio-frequency heating, are not retained because they would be ineffective on LNAPL of such a minimal thickness.

Removal. Multi-phase extraction and LNAPL skimming are retained.

Disposal. Permitted discharge and off-site disposal are retained for combination with other technologies.

Based on the screening of technologies, the following are retained for assembling into remedial alternatives for LNAPL near Plant B:

- No Action
- Deed covenants
- Sampling and Analysis
- Multi-phase Extraction
- LNAPL Skimming
- Permitted Discharge
- Off-site Disposal

2.3.2.2. Reduction of DAPL volume and mass of DAPL constituents

Table 2.3-2 presents the technology screening for reduction of DAPL volume and DAPL constituent mass. Technologies and process options judged ineffective or not implementable were not retained. The retained technologies and process options are those considered most suitable for remediation of DAPL. The retained technologies/process options may be used alone or integrated with other technologies to develop remedial alternatives.

The following paragraphs summarize the results of technology screening for DAPL:

Institutional Controls. Technologies identified that may be used as components of remedial alternatives to provide institutional controls are deed covenants and sampling and analysis.

Containment. Containment technologies were not retained because of their implementation difficulty given the industrial nature of the areas above the DAPL pools. The high density of structures, including buildings, subsurface utilities, private properties, and transportation infrastructure would render the installation of containment structures infeasible. There is also a mixture of property types, including private property and Town property. These circumstances are quite different from the already-constructed Slurry Wall Containment Area around the on-property DAPL pool, where these types of physical obstructions were not present. These circumstances would also complicate efforts to verify the competent installation of containment structures.

Containment of the Off-PWD and Main Street DAPL pools would not enhance extraction or alleviate impacts to bedrock groundwater that have already occurred. Hydraulic containment was not retained because the DAPL is already contained from migration by its own gravimetric properties and the natural subsurface geology.

Treatment. Specific treatment technologies for extracted DAPL are not retained at this time. Olin however is in the process of evaluating on-site treatment as an option to current off-site disposal and is discussed in more detail in Section 3. Many of the treatment technologies are ineffective on the complicated mix of DAPL-related COPCs. Others, such as in-situ chemical oxidation, have the potential to increase toxicity. Air sparging is not retained due to its potential to convectively mix the DAPL with overlying groundwater and increase mobility of COPCs nor its ability to reduce the mass of most DAPL-related COPCs. Due to the contained nature of the DAPL pools, DAPL would not be expected to move through a permeable reactive barrier for treatment. Adsorption is not retained due to the potential for iron fouling and its inability to affect the mass of some DAPL-related COPCs, and break-point chlorination is not retained as a standalone technology because it requires low turbidity and low dissolved solids, it may result in unwanted chlorinate byproducts, and would be ineffective for some DAPL-related constituents making it unsuitable for a DAPL source control technology.

Removal. DAPL extraction is retained. Based on the DAPL Extraction Pilot Study and on-going DAPL extraction of the off-PWD DAPL Pool, extraction of DAPL appears to be feasible and implementable, at least in the short term. As discussed previously, limited lateral migration of DAPL and diffuse groundwater also appears to have occurred within the shallow weathered bedrock, where present, adjacent to and down slope of the DAPL pools. While physical extraction is a viable way to remove DAPL from the overburden, it is highly unlikely that all DAPL can be removed. Some amount of DAPL will remain in both the alluvial overburden soils and the weathered bedrock, and it is likely that a certain amount of residual DAPL will also remain on the bedrock surface in the depressions where DAPL pools have formed. In addition, not all the DAPL present in overburden porosity will freely drain by gravity. Therefore, DAPL extraction is not likely to remove all DAPL.

Disposal. Permitted discharge and off-site disposal are retained for combination with other technologies. The DAPL currently being extracted from the off-PWD DAPL Pool is being shipped off-site for disposal at two permitted commercial hazardous waste facilities: (1) a wastewater treatment facility (in Indiana) where waste streams are treated and blended prior to permitted discharge, and (2) a deep well injection facility (in Ohio). Currently, the majority of DAPL (approximately 90% or more) is disposed through deep well injection. DAPL is extremely complex to treat chemically, and a commercially-viable on-site treatment option that would not include some measure of off-site disposal has not been developed at present.

Based on the screening of technologies, the following are retained for assembling into interim action alternatives for DAPL:

- No Action
- Deed covenants
- Sampling and Analysis
- DAPL Extraction
- Permitted Discharge
- Off-site Disposal

2.3.2.3. Manage downgradient migration of higher-concentration groundwater (NDMA concentrations =/> 11,000 ng/L) downgradient of DAPL pools in the Ipswich Watershed

Table 2.3-3 presents the technology screening for groundwater migration management. Technologies and process options judged ineffective or not implementable were not retained. The retained technologies and process options are those considered most suitable for groundwater migration management. The retained technologies/process options may be used alone or integrated with other technologies to develop interim action alternatives.

The following paragraphs summarize the results of technology screening for groundwater:

Institutional Controls. Technologies identified that may be used as components of remedial alternatives to provide institutional controls are deed covenants, bottled water, and sampling and analysis.

Monitored Natural Attenuation. Monitored Natural Attenuation was not retained as an interim action, source control technology for DAPL.

Treatment. Table 2.3-3 includes various in-situ and ex-situ treatment technologies typically evaluated for groundwater. Enhanced biodegradation is retained for the potential to oxidize NDMA through co-metabolic biodegradation, a technology that is still in the laboratory development phase and is not yet proven at field scale. Air stripping, air sparging/soil vapor extraction, chemical reduction/oxidation permeable reactive barrier, and break-point chlorination were not retained because they were either ineffective for the OCSS COPCs and/or could increase toxicity and mobility of OCSS COPCs (of note, enhanced biodegradation also has the potential to oxidize trivalent chromium to hexavalent chromium). UV oxidation was retained for its effectiveness in treating NDMA. Adsorption is retained due to being somewhat effective for ammonia and chromium. The existing Municipal Water Treatment Plant is retained; the Town of Wilmington Water Treatment Plant could be reactivated for use.

Containment/Removal. Groundwater extraction and Municipal Water Supply Wells are retained.

Disposal. Permitted discharge is retained for combination with other technologies.

Based on the screening of technologies, the following are retained for assembling into remedial alternatives for groundwater:

- No Action
- Deed covenants

- Sampling and Analysis
- Enhanced Biodegradation
- Adsorption
- UV Oxidation
- Existing Municipal Water Treatment Plant
- Groundwater Extraction
- Municipal Water Supply Wells
- Permitted Discharge

2.3.2.4. Hydraulic Isolation of Containment Area Soils

Table 2.3-4 presents the technology screening for the Containment Area. Since the focus for the Containment Area is capping and removal, in-situ and ex-situ treatment technologies have not been considered. Technologies and process options identified that were judged ineffective or not implementable were not retained. The retained technologies and process options are those considered most suitable for capping or removal of Containment Area soils. The retained technologies/process options may be used alone or integrated with other technologies to develop remedial alternatives. Based on the screening of technologies, the following are retained for assembling into remedial alternatives for the Containment Area.

The following paragraphs summarize the results of technology screening for the Containment Area.

Institutional Controls. Technologies identified that may be used as components of remedial alternatives to provide institutional controls are deed covenants and sampling and analysis.

Containment. Four types of capping scenarios were identified for the containment general response action, similar to the previously submitted OU1/OU2 FS. However, only the RCRA Subtitle C and Subtitle D options were retained for development into remedial alternatives.

Removal. Mechanical excavation was identified as the removal technology to be retained for development of remedial alternatives.

Disposal. Both on-site and off-site disposal were identified as common disposal options. However, any soil that potentially may be excavated is within the Containment Area, which is currently capped with a temporary cover and has been proposed for a more permanent cover. Removing soil from the Containment Area and disposing elsewhere on-site is not considered a viable approach to site remediation. Therefore, only off-site disposal was retained for development into remedial alternatives.

Based on the screening of technologies, the following are retained for assembling into remedial alternatives for the Containment Area:

- No Action
- Deed covenants
- Sampling and Analysis
- RCRA Subtitle D Cap
- RCRA Subtitle C Cap
- Mechanical Excavation
- Off-Site Disposal

3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

In this section, alternatives are developed to meet the IAOs presented in Subsection 2.1, using the general response actions identified in Subsection 2.2 either individually or in combination. Developed remedial alternatives are then screened with respect to the criteria of effectiveness, implementability, and cost to meet the requirements of CERCLA and the NCP (40 CFR 300.430(e)(7)). An interim action FS is typically a streamlined and focused evaluation, wherein a narrower range of technologies and alternatives should be tailored to the specific scope and purpose of the interim action. This document in general follows the screening process for a normal FS that includes a more detailed evaluation process for developing final remedies.

3.1 Alternative Screening Criteria.

The objective of the alternative screening step is to eliminate impractical alternatives or higher cost alternatives (i.e., order of magnitude cost differences) that provide little or no increase in effectiveness or implementability over their lower-cost counterparts. The effectiveness and implementability criteria used for screening the alternatives are discussed in the following paragraphs.

Effectiveness. This criterion focuses on the degree to which an alternative reduces toxicity, mobility, and/or volume through treatment, minimizes residual risks and affords long-term protection, complies with ARARs and minimizes short-term impacts. The NCP indicates that both short- and long-term aspects of effectiveness should be considered. Short-term is considered to be the construction and implementation period, while long-term begins once the interim remedial action is complete and IAOs have been met. Short-term effectiveness considerations include the effects of the alternatives during the construction and implementation period, the alternative's ability to meet IAOs, and the relative time frame required to achieve IAOs. Long-term effectiveness considers the magnitude of the remaining residual risk because of residual contaminant sources, and the adequacy and reliability of specific technical components and control measures to maintain compliance with IAOs over the life of the remediation. Alternatives that do not meet the IAOs are eliminated from further consideration.

Implementability. Each alternative is also evaluated in terms of technical and administrative feasibility. In the assessment of short-term technical feasibility, availability of a technology for construction or mobilization and operation, as well as compliance with action-specific ARARs during the remedial action, are considered. Long-term technical feasibility considers the ease of operation and maintenance, technical reliability, the ease of undertaking additional remedial actions, and the degree of monitoring or controls for residuals and untreated wastes.

Administrative feasibility for implementing a given technology addresses the ability to obtain approvals from pertinent offices and agencies for off-site activities, the availability of treatment storage and disposal services, and the commercial availability of required services and trained specialists or operators. Alternatives that are technically or administratively infeasible or that would require equipment, specialists, or facilities that are not available within a reasonable period of time may be eliminated from further consideration (NCP, 40 CFR 300.430(e)(7)).

Costs. This criterion considers the costs of construction and long-term costs to operate and maintain the alternatives. As noted in USEPA guidance, the overall goal of the remedy selection process is to remediate contaminated sites to the maximum extent practicable, which requires a co-equal mandate for remedies to be cost-effective (USEPA, 1988b). Costs that are grossly excessive compared to the overall effectiveness of alternatives may be considered as one of several factors used to eliminate alternatives. Alternatives providing effectiveness and implementability similar to that of another alternative by employing a similar method of treatment or engineering control, but at greater cost, may also be eliminated (NCP, 40 CFR 300.430(e)(7)).

This section does not formally evaluate costs. Rather, based on knowledge of relative costs, professional judgment is used to identify the relative cost-effectiveness of each alternative. Detailed cost evaluations will be performed as part of the detailed evaluation of those alternatives passing this section's screening.

The No Action Alternative is not evaluated according to the screening criteria; it will pass through screening to be evaluated during the detailed analysis as a baseline for other retained alternatives (USEPA, 1988b).

3.2 Identification and Development of Alternatives

Based on the screening of technologies and process options presented in Subsection 2.3 and **Table 2.3-1 through Table 2.3-4**, the following interim action alternatives have been assembled for LNAPL, DAPL, downgradient groundwater migration, and the Containment Area.

<u>LNAPL</u>

Alternative LNAPL 1: No Action

Alternative LNAPL 2: Manual Recovery

Alternative LNAPL 3: Continual Mechanical Recovery

Alternative LNAPL 4: Multi-Phase Extraction

DAPL

Alternative DAPL 1: No Action

Alternative DAPL 2A: DAPL Extraction from Off-PWD DAPL Pool

Alternative DAPL 2B: DAPL Extraction from On-Property DAPL Pool

Alternative DAPL 2C: DAPL Extraction from Main Street DAPL Pools

Groundwater

Alternative GW 1: No Action

Alternative GW 2A: Groundwater Extraction via MWSWs with Treatment for Potable Use by Additions to Municipal Water Treatment Plant

Alternative GW 2B: Groundwater Extraction via MWSWs with Treatment for Surface Water Discharge by Additions to Municipal Water Treatment Plant

Alternative GW 3: Groundwater Extraction via New Wells and Treatment via New Water Treatment Plant for Surface Water Discharge

Alternative GW 4: Groundwater Extraction via Butters Row MWSWs and Treatment via New Water Treatment Plant for Surface Water Discharge

Alternative GW 5: Groundwater In-Situ Biological Treatment

Containment Area

Alternative CA 1 1: No Action

Alternative CA 2: Capping, Closure of the Equalization Window, and Institutional Controls

Alternative CA 3: Soil Removal

3.2.1 LNAPL Remedial Alternatives

This section summarizes the remedial alternatives for removal of mobile LNAPL.

3.2.1.1. Alternative LNAPL 1: No Action

The No action alternative does not include remedial action components to enhance recovery of LNAPL. In the No Action Alternative, institutional controls would be maintained, and efforts currently implemented to recover LNAPL would continue. The No Action alternative provides a baseline for comparison with the other developed alternatives as required by CERCLA and the NCP.

3.2.1.2. Alternative LNAPL 2: Manual Recovery

Alternative LNAPL 2 consists of maintaining current institutional controls (with revisions that may be required by USEPA under CERCLA) that prevent excavation and use of groundwater near Plant B, and manual recovery of LNAPL from the existing extraction well IW-11 at Plant B. LNAPL is currently recovered via a skimmer bucket on a monthly basis and totals less than one gallon per year recovered. This alternative would include additional recovery efforts using absorbent socks in wells where measurable LNAPL is observed (GW-23 for example). The recovered LNAPL would be stored on-site until being disposed of in accordance with RCRA regulations.

3.2.1.3. Alternative LNAPL 3: Continual Mechanical Recovery

Alternative LNAPL 3 consists of maintaining current institutional controls (with revisions that may be required by USEPA under CERCLA) that prevent excavation and use of groundwater near Plant B, and continual mechanical recovery of LNAPL from three new recovery wells at Plant B. **Figure 3.2-1** depicts assumed locations for the recovery wells which are in the area where LNAPL is most frequently observed between the foundation of Plant B and IW-11. Each of the recovery wells would contain an automated skimmer. The skimmer contains a hydrophobic/oleophilic filter that allows LNAPL to collect inside the skimmer without also entraining water. The skimmer periodically pumps the collected LNAPL out of the well to a drum for storage. The skimmers fluctuate with the water table to keep the collection port at the product/water interface. The skimmers' pumps are actuated by a central controller. The recovered LNAPL would be stored on-site until being disposed of in accordance with RCRA regulations.

3.2.1.4. Alternative LNAPL 4: Multi-Phase Extraction

Alternative LNAPL 4 consists of maintaining current institutional controls (with revisions that may be required by USEPA under CERCLA) that prevent excavation and use of groundwater near Plant B, and high vacuum multi-phase extraction (MPE) of LNAPL from a new recovery well located just outside the northeast corner of the Plant B Treatment Building where the thickest accumulation of LNAPL is observed (near GW-23). The multi-phase extraction system will be skid-mounted and rented from an environmental contractor. A slurp tube is lowered to above the water table and high vacuum applied which pulls the water table up around the well. The slurp tube is then progressively lowered into the water table to point that produces a little drawdown. The vacuum pulls water, air and LNAPL phases along the capillary zone to the well. The skid-mounted system is completely automated and includes the extraction blower, knockout tank to separate the streams, and vapor treatment, if necessary. As these phases are pulled into the vacuum side, an automated switch momentarily allows the fluid in the accumulation tank to go to atmosphere and it is transferred to an oil/water separator so the water stream can be separated from the LNAPL. The recovered LNAPL would be stored on-site until being disposed of in accordance with RCRA regulations. Water would be pretreated and sent to Plant B for final treatment and discharge. The skid-mounted system is rented for up to 12 months. LNAPL recovery through MPE decreases over time, and significant amounts of LNAPL are unlikely to be recovered past 12 months.

3.2.2 DAPL Remedial Alternatives

This section summarizes the remedial alternatives for removal of DAPL. The on-going DAPL extraction at the off-PWD has been demonstrated to be successful and therefore this demonstrated approach is proposed for all three DAPL pools. The pilot study confirmed that the rate of DAPL extraction is a function of the geometry of the DAPL pools consistent with published literature (Dorgarten and Tsang, 1990). The off-PWD and the on-Property DAPL pools both have shallow bedrock bottom slopes that will limit sustainable DAPL extraction rates. The Main Street DAPL pool, as interpreted by Olin, has steeper slopes and several low points when compared to off-PWD pool. The Main Street DAPL pool likely can sustain higher extraction rates from wells located in these low points. Therefore, alternatives have been developed based upon Olin's understanding of what might constitute an optimal extraction approach and strategy. Each alternative is intended to match sustainable gravity flow and therefore each alternative is believed to be aggressive given Olin's experience at the off-PWD. Given this, Olin is proposing appropriate number of extraction wells at each DAPL pool given the configuration and constraints (including buildings) at each DAPL pool. It should be noted that excessive extraction rates that yield greater hydraulic drawdowns is an ineffective means of removing DAPL from the subsurface. Lessons learned from operation of the OPWD DAPL extraction system indicate that such excessive drawdown results in developing a cone of lesser impacted diffuse and overlying groundwater around the extraction well screen such that very little DAPL is actually removed. Optimal pumping rates, while seemingly minimal, are designed to maximize the amount of DAPL extracted over time without dilution.

Number of Wells and Extraction Rates. The table below considers number of wells and expected per well extraction rates to estimate optimal expected timeframes for DAPL removal. This assumes an overall 80% operation time over the life of the system (20% down time for maintenance/recovery. Note, the utilized % downtime is based on the operational data collected from the ongoing operation of off-PWD DAPL extraction system).

DAPL Pool	Number of Wells	Extraction Rate (GPM) [3.]	DAPL Volume (Gallons)	Operating Time	Removal Time Frame (Years)
Main Street DAPL Pool	1	2	13,000,000	80%	15.5
	2	2	13,000,000	80%	7.7
	3	2	13,000,000	80%	5.2
Off-PWD DAPL Pool [1.]	1	0.25	1,000,000	80%	9.5
	2	0.25	1,000,000	80%	5.5
On-Property DAPL Pool [2.]	1	0.25	200,000	80%	1.9

Notes

1. Well not included in costs. Second well to be added at start of year 3 if geophysical investigation results indicate installation of second extraction well is appropriate. The potential addition of the second well reduces the overall removal time frame to ~5.5 years
2. Single central well
3. Extraction rates utilized in the calculations are based on current understanding of bedrock topography and step-down test performed during the start-up of the off-PWD DAPL extraction system.

GPM = gallons per minute

Olin believes vertical wells offer the best control over depth and location of DAPL extraction as well as maintenance and has assumed vertical wells for this evaluation. Consideration of other well installation methods such as directional drilling is discussed under development of each individual alternative.

<u>Management Alternatives for Extracted DAPL</u>. Olin is evaluating alternative means of managing extracted DAPL through options including off-site disposal as well as on-site treatment and volume reduction. DAPL is an extremely complicated fluid to treat due to its acidity, and content of total dissolved solids (principally sulfates), ammonia, and NDMA. Development of a treatment train to provide cost and effectiveness information would require bench scale feasibility work and preliminary design best accomplished in the remedial design process. It is expected that all treatment train options would require residual management, and whether that residual is a hazardous or non-hazardous material will be a function of the treatment processes and residual stabilization process options should they be demonstrated feasible. Olin has evaluated off-site disposal with no on-site treatment as this is currently an alternative which has been confirmed to be feasible. If during the design process an on-site treatment train is found to be feasible and effective better remedy component, then Olin will recommend such treatment to USEPA as the

appropriate option. USEPA has also offered input from their Office of Research and Development (ORD) to assist with evaluation of on-site treatment technologies. Olin remains interested in engaging the USEPA ORD for said purpose. Along with full off-site disposal, Olin is currently considering the following on-site treatment options:

- Brine concentration to reduce the liquid volume for disposal
- Brine concentration to a solid phase to eliminate management of a liquid waste for disposal. Options include stabilization of the solid residual to eliminate potential hazards associated with chromium and ammonia.

Pretreatment prior to brine concentration to remove metals and ammonia to reduce or eliminate potential hazards associated the solid residuals. Pretreatment will likely require a variety of different unit operations to attain the appropriate treatment goals (i.e., to minimize the amount of treatment residuals required to be disposed of off-site).

3.2.2.1. Alternative DAPL 1: No Action

The No action alternative does not include remedial action components to reduce volume of DAPL, or control or eliminate potential risks from exposure to DAPL. The No Action alternative provides a baseline for comparison with the other developed alternatives as required by CERCLA and the NCP.

3.2.2.2. Alternative DAPL 2A: DAPL Extraction from Off-PWD DAPL Pool

Alternative DAPL 2A consists of institutional controls, continued operation of the DAPL extraction system in the Off-PWD DAPL Pool, O&M, groundwater monitoring, and Five-Year Site Reviews.

In this alternative, the current DAPL extraction system would continue to extract DAPL at a rate not to exceed the gravity-driven rate of drainage towards the extraction well. The extracted DAPL would be pumped to the Olin Property where it would be stored and then disposed of by a permitted hazardous waste disposal company. This alternative would also include DAPL pool and surrounding groundwater monitoring and Five-Year Site Reviews. It is anticipated this alternative would have a minimum duration of approximately 6 to 10 years at 0.25 gpm extraction rate. The range is dependent on whether investigation confirms that a second well location is appropriate based on bedrock configuration as described below.

This alternative will include installation of a new extraction well adjacent to EW-1 with a two-foot screen to replace the existing EW-1. The shorter screen length will reduce the amount of intrusion of overlying groundwater into and impinging on the screen and improve the efficiency of DAPL extraction. The shorter screen does not affect the rate of gravity drainage to the well, but may allow slightly improved pumping rates without dilution. The current geophysical data indicates that the slope of bedrock is from east to west under the existing building where the central portion of the pool is located. The alternative will include installing borings to bedrock on the northeast and southeast side of the building to confirm bedrock elevations and current geophysical data. If the general slope of bedrock is confirmed to be east to west, then the current extraction well is located properly for removing DAPL via gravity drainage long-term. The slope of the bedrock will determine long-term sustainable recovery rates, which may be greater than 0.25 gpm depending on the geometry of the pool. Evaluating more aggressive extraction rates is not feasible without additional information, which can be obtained in the design phase. If the boring data indicates a second well could be installed to improve DAPL recovery rates, an extraction well will be installed on the eastern side of the pool as part of this interim action. It should be noted that the area available for well installation is limited by existing buildings and infrastructure. Depending on results and surface obstructions, consideration would be given to directional drilling as a well installation option.

3.2.2.3. Alternative DAPL 2B: DAPL Extraction from On-Property DAPL Pool

Alternative DAPL 2B consists of institutional controls, installation and operation of a DAPL extraction system for the On-property DAPL Pool, O&M, groundwater monitoring, and Five-Year Site Reviews.

In this alternative, a DAPL extraction system similar to the one installed for the Off-PWD DAPL Pool would be installed in the On-Property DAPL Pool and used to extract DAPL at a rate not to exceed the gravity-driven rate of drainage towards the extraction well. The extracted DAPL would be pumped to the storage tank on Olin Property where it would be stored prior to transport to an off-site permitted hazardous waste disposal facility, similar to the current process being used for the Off-PWD DAPL Pool. This alternative would also include groundwater monitoring and Five-Year Site Reviews.

Geophysical surveys will be conducted to locate the low point of the bedrock depression within the Containment Area to guide location of a centrally-located extraction well. The On-Property DAPL pool is small. Calculations have estimated that as little as 190,000 gallons of DAPL may be present. As such, installation of multiple extraction wells is unnecessary to remove the DAPL in a reasonable time frame. Current information indicates bedrock surfaces slope gently beneath the area where DAPL is located. Therefore, sustainable gravity-driven extraction rates are expected to be similar to those of the off-PWD system. It is anticipated this alternative would have a duration of approximately two years at 0.25 gpm extraction rate. Extraction rates will be evaluated as part of the design process and subsequent operation.

3.2.2.4. Alternative DAPL 2C: DAPL Extraction from Main Street DAPL Pool

Alternative DAPL 2B consists of institutional controls, installation and operation of a DAPL extraction system for the Main Street DAPL Pool, O&M, groundwater monitoring, and Five-Year Site Reviews.

The current understanding of bedrock topography in the DAPL pool indicates substantial heterogeneity that would preclude the installation of a horizontal well into the bedrock low points. Vertical extraction wells are better suited for this alternative. As described below, Olin believes that a series of vertical extraction wells will allow removal of the Main Street DAPL pool, to the extent practicable, in approximately, as little as six years. A DAPL extraction system similar to the one in the Off-PWD DAPL Pool would be installed in the Main Street DAPL Pool and used to extract DAPL at a rate not to exceed the gravity-driven rate of drainage towards the extraction wells. Three extraction wells would be installed in the Main Street DAPL pool at locations that appear to be the lowest points based on all available boring and seismic information. The proposed locations (subject to change) of the extraction wells are shown on **Figure 3.2-2**. The extracted DAPL would be pumped to the Olin Property where it would be stored prior to transport to an off-site permitted hazardous waste disposal facility, similar to the current process being used for the Off-PWD DAPL Pool. This alternative would also include groundwater monitoring and Five-Year Site Reviews. It is anticipated this alternative would have a minimum duration of five to six years assuming an initial 2.0 gpm extraction rate for each of three extraction wells is sustainable based on bedrock topography and would continue until DAPL is removed to the extent practicable .

3.2.3 Groundwater Alternatives

This section summarizes the remedial alternatives for groundwater (management of migration).

We have evaluated groundwater extraction alternatives to manage migration. In this process we have identified to what extent the plume is currently migrating and where wells can be installed to effectively capture the plume and control migration. Review of historical NDMA data indicates the plume had not migrated to and beyond GW-73D near Town Park Well in 2003 and 2004. Therefore GW-73D was down gradient of the plume during operation of the five Wilmington MWSWs in MMB. Since cessation of pumping the plume has migrated to and past GW-73D and NDMA is detected in GW-404D/BR.

The only accessible and logical locations for extraction wells capable of managing this downgradient migration include reuse of Butters Row 1 and 2 or installation of new wells along the access road for GW-65D adjacent to the Middlesex Canal[1]. Extension of this access road, if needed, would be entirely feasible and provide access for construction and long-term maintenance and operation of new extraction well heads. **Figure 3.2-3** provides a recent photographic perspective of MMB from the Maple Meadow Brook Aqueduct of the Middlesex Canal. This figure illustrates some of the issues discussed above including the current GW-65D access which is on property owned by the Middlesex Canal Association. Any activities here would require agreement with the Association.

The diffuse groundwater in the downgradient core of the plume that contributes to this contaminant migration is in deep overburden groundwater beneath the confluence of Saw Mill and Maple Meadow Brooks (in vicinity of GW-86D and GW-87D). This area is approximately 600 feet upgradient from the former Middlesex Canal, where GW-65D is located. While the highest concentrations of NDMA occur near GW-84D and GW-83D which are located in the middle of the MMB wetland these wells are approximately 1,000 and 1,500 feet upgradient of GW-65D respectively and groundwater extraction near these "hotspots" would not affectively contain groundwater currently migrating past GW-65D. Groundwater extraction near GW-65 would have immediate effect in controlling plume migration. The NDMA plume extends approximately 1,100 feet past GW-65D. Impacted groundwater currently beyond GW-65D would attenuate naturally.

Plates 2-3 and 2-4 from the Smith Phase II Report (Smith, 1997), provided previously to USEPA are provided in Appendix C for convenience. These plates show the shallow and deep groundwater potentiometric surface in October 1995 and indicate the extent of drawdown related to the radius of influence of the MWSWs Butters Row 1 and Butters Row 2 to have been approximately 600 feet. These data indicate Butter Row 1 captured groundwater in the vicinity of GW-86D and GW-87D. Butters Row 2 captured groundwater to the far side of the Middlesex Canal bridge abutment, approximately 200 feet past (east of) GW-65D to the edge of the wetland. Re-activation of these MWSWs could also control migration.

[1]The Middlesex Canal Corporation was formed in 1793 by a charter signed by John Hancock and funded by investors that included John Hancock and John Quincy Adams. Being completed in 1803 it connected the Merrimack River at Lowell with the Charles River at Boston; a distance of 27 miles for commerce. The canal is listed as an Historic Civil Engineering Landmark and is subject provisions of a 1972 listing on the National Register of Historic Places.

Most recent NDMA concentrations in deep overburden groundwater range from over 2,000 to 200 ng/L within the capture zone of Butters Row 1 and 2, respectively. Although USEPA has indicated a preference to conduct groundwater extraction in the vicinity of areas of groundwater where NDMA is greater than 11,000 ng/L, such areas are located more than 1,000 feet upgradient from the downgradient plume core.

Management of migration of the plume by extraction of groundwater from these distant, higher concentration areas would be ineffective and infeasible. These areas where such concentrations are evident or likely are within inaccessible portions of the MMB wetland where installation, and more importantly, long term operation and maintenance of well heads would be entirely impractical, if not impossible. Installation of a well would require construction of a road from a privately owned property out into the MMB wetland over geotechnically unsuitable substrates underlain by several 10s of feet of peat deposits. Such a road and well head structures would need to be substantial and geotechnically supported to remain stable and above the elevation of annual inundation of the wetland. Any well head structure would need to be robust and permanent given the conditions. Further, the wells itself will need to have electrical and electronics infrastructure, which poses practical challenges to install wells within the wetlands. In addition, design of such a structure and its feasibility would require an in-depth geotechnical investigation and mitigative measures, which could become cost-prohibitive. Even after all of this effort, extraction from such a location would have minimal immediate benefit and potentially minimal long-term benefit in managing the current and continued migration of high concentrations of NDMA and other COCs from residual sources farther downgradient in the plume core area. For these reasons Olin has concluded the only logical and prudent location for management of migration is as proposed, in vicinity of the GW-65 well series.

3.2.3.1. Alternative GW 1: No Action

The No Action alternative does not include remedial action components to reduce volume or mass of contaminants or to control migration or eliminate potential risks from exposure to groundwater. The No Action alternative provides a baseline for comparison with the other developed alternatives as required by CERCLA and the NCP.

3.2.3.2. Alternative GW 2A: Groundwater Extraction via MWSWs and Treatment for Potable Use with Additions to Municipal Water Treatment Plant

Alternative GW 2A consists of institutional controls, groundwater extraction via the Town MWSWs, treatment additions to the municipal water treatment plant, groundwater monitoring, and 5-Year Site Reviews. It is our understanding that the Butters Row Treatment Plant currently processes approximately 460,000 gallons per day (gpd) of raw water from the Wilmington Shawsheen water supply well for distribution.

In this alternative, two MWSWs that are currently inactive (Butters Row 1 and 2, see **Figure 1.4-2**) would be re-activated. The Butters Row Municipal Treatment plant would be upgraded with two UV oxidation units to treat NDMA and provide a reliable redundant system. If one UV system requires ordinary maintenance the other is ready to be placed on line. The combined water from the Shawsheen well and the Butters Row wells would be treated at the Butters Row municipal water treatment plant to achieve drinking water standards or risk-based target remediation levels (if drinking water standards are not available) for NDMA and other COCs. This treated water would then be available for potable use. This alternative would also include groundwater monitoring and Five-Year Site Reviews. Extraction rates would be dictated by Town needs.

It is important to note that this alternative is only viable if there is community acceptance and the Town agrees to re-activate the two former Butters Row MWSWs for groundwater extraction and treatment for potable use. If the Town wells are not reactivated, this alternative would need to be re-evaluated.

3.2.3.3. Alternative GW 2B: Groundwater Extraction via MWSWs and Treatment for Surface Water Discharge by Additions to Municipal Water Treatment Plant

Alternative GW 2B consists of institutional controls, groundwater extraction via the Town MWSWs, treatment additions to the municipal water treatment plant, groundwater monitoring, and 5-Year Site Reviews. As discussed above, it is our understanding that the Butters Row Treatment Plant currently processes approximately 460,000 gpd of raw water from the Wilmington Shawsheen water supply well for distribution. Extraction rates would be dictated by Town needs.

In this alternative, two MWSWs that are currently inactive (Butters Row 1 and 2, see **Figure 1.4-2**) would be re-activated. Water extracted from these wells would be treated at the municipal water plant such that treated water meets surface water discharge permit requirements. In addition, the treatment plant would be upgraded with a UV oxidation unit to treat NDMA to meet drinking water standards. This extracted water would then be discharged to surface water. This alternative would also include groundwater monitoring and Five-Year Site Reviews. This alternative would also require that the water from the Shawsheen water supply well be re-routed to the Sargent Water Treatment Plant for processing and that the Sargent plant has sufficient excess capacity.

It is important to note that this alternative is only viable if there is community acceptance and the Town agrees to reactivate the two former Butters Row MWSWs for groundwater extraction and treatment for surface water discharge. If the Town wells are not reactivated, this alternative would need to be reevaluated.

3.2.3.4. Alternative GW 3: Groundwater Extraction via New Wells and Treatment via New Water Treatment Plant

Alternative GW 3 consists of institutional controls, groundwater extraction using a new extraction well (or wells) to be installed near existing well GW-65S, treatment using a new water treatment plant to be constructed near the Butters Row Treatment Plant, groundwater monitoring, and Five-Year Site Reviews.

The new treatment plant would include a treatment train similar to the current municipal water treatment plant such that treated water meets surface water discharge permit requirements such that treated water meets surface water discharge permit requirements (for example ammonia, metals and inorganics). In addition, the treatment plant would include a UV oxidation unit to treat NDMA to meet risk-based target remediation levels. This extracted and treated water would then be discharged to surface water. This alternative would also include groundwater monitoring, capture analysis, and Five-Year Site Reviews.

Prior to remedial design, the pre-design investigation would develop hydraulic data to support calibration of the existing groundwater flow model. The groundwater flow model would then be updated and used to evaluate optimal well placement, number of wells, and pumping rates for groundwater capture. Such modeling would also provide quantitative insight on the vertical capture of underlying bedrock groundwater through pumping of deep overburden groundwater.

3.2.3.5. Alternative GW 4: Groundwater Extraction via Butters Row MWSWs and Treatment via New Water Treatment Plant

Alternative GW 4 consists of institutional controls, groundwater extraction using the existing Butters Row MWSWs, treatment using a new water treatment plant to be constructed near Butters Row, groundwater monitoring, and Five-Year Site Reviews.

In this alternative, two MWSWs that are currently shut down (Butters Row 1 and 2, see **Figure 1.4-2**) would be re-activated. Water extracted from these wells would be re-routed to a new treatment plant to be constructed near the Butters Row Treatment Plant. The new treatment plant would include a treatment train similar to the current municipal water treatment plant, such that treated water meets surface water discharge permit requirements. In addition, the treatment plant would be upgraded with UV oxidation units to treat NDMA to risk-based target remediation levels. This extracted and treated water would then be discharged to surface water. This alternative would also include groundwater monitoring and Five-Year Site Reviews.

It is important to note that this alternative is only viable if there is community acceptance and the Town agrees to re-activate the two former Butters Row MWSWs for groundwater extraction and treatment for surface water discharge. If the Town wells are not reactivated, this alternative would need to be reevaluated.

3.2.3.6. Alternative GW 5: Groundwater In-situ Biological Treatment

Alternative GW 5 consists of institutional controls, in-situ biological treatment to bring concentrations of NDMA to drinking water standards, groundwater monitoring, and Five-Year Site Reviews.

In this alternative, new injection wells would be installed in the vicinity of GW-65S and used to inject propane into the aquifer to promote and maintain conditions favorable to bioremediation of NDMA. This technology has been demonstrated at field-scale (Hatzinger and Lippincott, Environmental Security Technology Certification Program [ESTCP] 2015). However, a laboratory treatability study has been proposed to USEPA using site materials—soils and groundwater—to evaluate site-specific biodegradation rates of NDMA. This alternative would also include groundwater monitoring and Five-Year Site Reviews.

3.2.4 Containment Area Alternatives

Based on USEPA review of the OU1/OU2 FS and the OU3 FS (Amec Foster Wheeler, 2018c and d), the USEPA specifically requested that this IAFS include alternatives for soils within the Containment Area. Capping and excavation are the technologies that have been retained to fulfill this request. The purpose of capping is to improve hydraulic isolation by minimizing infiltration and elimination of hydraulic communication through the equalization window. Capping would also reduce leaching of constituents from unsaturated soil to groundwater.

Currently no health risk issue concerning soils within the Containment Area has been identified. USEPA has expressed concern that there may be uncharacterized soils that could pose a health risk and/or be a source to groundwater. Olin has conducted an evaluation of available soil data to evaluate whether soil removal should be a component of remedial actions at the Containment Area and has therefore evaluated soil removal as standalone alternative.

3.2.4.1. Alternative CA 1: No Action

The No Action alternative does not include capping or removal of soil that might reduce infiltration or leaching to groundwater or control or eliminate potential risks from exposure to soil within the Containment Area (beyond existing restrictions). The No Action alternative provides a baseline for comparison with the other developed alternatives as required by CERCLA and the NCP.

3.2.4.2. Alternative CA 2: Capping, Equalization Window Closure, and Institutional Controls

Alternative CA 2 consists of institutional controls, closure of the equalization window in the Containment Area Slurry Wall, and installation of a permanent cap over the Containment Area to replace the temporary cap installed previously. This alternative would also include long-term O&M and Five-Year Site Reviews.

The Draft OU1 OU2 FS presented several different cap alternatives. Only one cap alternative is considered herein. The OU1 OU2 FS recommended a Subtitle D cap with a geosynthetic clay liner (GCL) as the infiltration layer. The alternative considered herein provides a composite barrier that improves the hydraulic performance of that cap design by adding an overlying geomembrane on the GCL. Any leakage through imperfections in the geomembrane are sealed by hydration of the bentonite clay in the underlying GCL. The GCL is not subject to desiccation problems due to freeze/thaw cycles common to clay soil liners in composite caps. The composite cap proposed will provide hydraulic performance equal to or better (lower) than the hydraulic conductivity of the slurry wall. The longevity of the material used in the proposed cap would long outlast any other future development components constructed over it.

3.2.4.3. Alternative CA 3: Soil Removal

Alternative CA 3 would consist of identification and removal of soil within the Containment Area that have high potential for leaching of constituents to groundwater. Institutional controls to prevent human access to these soils are currently in place. Because potentially contaminated soil would be removed, long-term monitoring and Five-Year Site Reviews would not be required.

3.3 Screening of Alternatives

During this step of the FS process, the alternatives that have been developed are screened against the effectiveness, implementability, and cost criteria as described in Subsection 3.1. The objective of the alternative screening step is to eliminate impractical or economically infeasible alternatives (i.e., order of magnitude cost differences when compared to return on investments) that provide little or no increase in effectiveness or implementability over their lower-cost counterparts. The alternatives retained during this screening step are then carried through a detailed evaluation.

3.3.1 LNAPL Alternatives

This section provides the preliminary screening of LNAPL alternatives.

3.3.1.1. Alternative LNAPL 1

Alternative LNAPL 1 is the no action alternative, which is required to be retained and typically is used only as a baseline comparison to other remedial alternatives. Alternative LNAPL 1 is not effective: it does not reduce toxicity, mobility, or volume, and will not meet the IAO to enhance recovery of LNAPL. Alternative LNAPL 1 can readily be implemented and is retained for detailed analysis.

3.3.1.2. Alternative LNAPL 2: Manual Recovery

Alternative LNAPL 2 includes institutional controls, manual recovery of LNAPL enhanced by installation of absorbent socks in wells that contain measurable product, monitoring, and 5-year Reviews. This alternative is effective: it reduces toxicity, mobility, and volume, through removal of LNAPL and meets the IAO to enhance recovery of LNAPL. The alternative is readily implementable, and has a low relative cost. Alternative LNAPL 2 is retained for detailed analysis.

3.3.1.3. Alternative LNAPL 3: Continual Mechanical Recovery

Alternative LNAPL 3 includes institutional controls, continual mechanical recovery of LNAPL, monitoring, and 5-year Reviews. Alternative LNAPL 3 is effective: it reduces toxicity, mobility, and volume, and also meets the IAO to enhance LNAPL recovery during implementation. The components for mechanical recovery are well-proven remedial technologies and are readily implemented, and has low relative cost. Alternative LNAPL 3 is retained for detailed analysis.

3.3.1.4. Alternative LNAPL 4: MPE

Alternative LNAPL 4 includes institutional controls, MPE of LNAPL at the northeast corner of the Plant B building, monitoring, and 5-year Reviews. This Alternative is effective: it reduces toxicity, mobility, and volume, and also meets the IAO to enhance LNAPL recovery during implementation. The alternative is expected have a short duration (several months to a year) and the components for MPE are well-proven remedial technologies that are readily implemented and has low relative cost. Alternative LNAPL 4 is retained for detailed analysis.

3.3.2 DAPL Alternatives

This section provides the preliminary screening of DAPL alternatives.

3.3.2.1. Alternative DAPL 1

Alternative DAPL 1 is the no action alternative, which is required to be retained and typically is used only as a baseline comparison to other remedial alternatives. This alternative is not effective: it does not reduce toxicity, mobility, or volume, and will not meet the IAO to reduce, to the extent practicable, mobility or volume of DAPL. It is readily implemented and has no cost. Alternative DAPL 1 is retained for detailed analysis.

3.3.2.2. Alternative DAPL 2A: DAPL Extraction in the Off-PWD DAPL Pool

Alternative DAPL 2A includes institutional controls, DAPL extraction in the Off-PWD DAPL Pool, monitoring, and 5-year Reviews. This alternative is effective: it reduces the volume of DAPL to the extent practicable, and institutional controls will prevent human exposure to DAPL. The components for DAPL extraction are well-proven and have been pilot-tested at the Site. It is readily implemented and has a relative high cost. Alternative DAPL 2A is retained for detailed analysis.

3.3.2.3. Alternative DAPL 2B: DAPL Extraction in the On Property DAPL Pool

Alternative DAPL 2B includes institutional controls, DAPL extraction in the On Property DAPL Pool, monitoring, and 5-year Reviews. Alternative DAPL 2B would be effective: DAPL extraction will reduce the volume of DAPL to the extent practicable, and institutional controls will prevent human exposure to DAPL. The components for DAPL extraction are well-proven and have been pilot-tested at the Site. It is readily implemented and has a high relative cost. Alternative DAPL 2B is retained for detailed analysis.

3.3.2.4. Alternative DAPL 2C: DAPL Extraction in the Main Street DAPL Pool

Alternative DAPL 2C includes institutional controls, DAPL extraction in the Main Street DAPL Pool, monitoring, and 5-year Reviews. Alternative DAPL 2C would be effective: it will reduce the volume of DAPL to the extent practicable, and institutional controls will prevent human exposure to DAPL. The components for DAPL extraction are well-proven and have been pilot-tested at the Site. Appropriate locations for well installation are accessible and the alternative is readily implementable although has a relative high cost. Alternative DAPL 2C is retained for detailed analysis.

3.3.3 GW Alternatives

This section provides the preliminary screening of groundwater alternatives.

3.3.3.1. Alternative GW 1

Alternative GW 1 is the no action alternative, which is required to be retained and typically is used only as a baseline comparison to other remedial alternatives. It is not effective: it does not manage downgradient migration of higher-concentration of NDMA in groundwater within the Ipswich Watershed and therefore will not meet the IAO for groundwater in the Ipswich watershed. Alternative GW 1 can be readily implemented and has no cost. Alternative GW 1 is retained for detailed analysis.

3.3.3.2. Alternative GW 2A: Groundwater Extraction via MWSWs with Treatment for Potable Use by Additions to Municipal Water Treatment Plant

Alternative GW 2A includes groundwater extraction via MWSWs with treatment for potable use by additions to municipal water treatment plant, monitoring, and 5-year Reviews. Based on historic pumping data, this alternative would be effective in managing downgradient migration of higher-concentration of NDMA in groundwater by capturing groundwater that is currently migrating down the Maple Meadow Brook aquifer and therefore meets the groundwater-specific IAO. Potable use of treated groundwater would be protective of public health because treatment would remove constituents of concern at concentrations that are 1) associated with cancer risk greater than $1x10^{-4}$ and/or hazard Index greater than one, and 2) above drinking water Maximum Contaminant Levels. The components for groundwater extraction via MWSWs with treatment for potable use by additions to the municipal water treatment plant are well-proven and are in use in the water treatment industry. The alternative is implementable although relatively high cost. Alternative GW 2A is retained for detailed analysis.

3.3.3.3. Alternative GW 2B: Groundwater Extraction via MWSWs with Treatment for Surface Water Discharge by Additions to Municipal Water Treatment Plant

Alternative GW 2B includes groundwater extraction via MWSWs with treatment for surface water discharge by additions to municipal water treatment plant, monitoring, and 5-year Reviews. Based on historic pumping data, this alternative would be effective in managing downgradient migration of higher-concentration groundwater by capturing groundwater that is currently migrating down the Maple Meadow Brook aquifer and therefore meets the groundwater-specific IAO. Since the groundwater would be treated to meet surface water discharge requirements and protective levels for NDMA in drinking water, the alternative is protective of human health and the environment.

The components for groundwater extraction via MWSWs with treatment for surface water discharge are well-proven and in use in the industry. Since this alternative would require re-routing of the Shawsheen Well raw water to the Sargent Treatment Plant it would be more difficult to implement and its relative cost would be higher than alternative GW 2A. Alternative GW 2B is retained for detailed analysis.

3.3.3.4. Alternative GW 3: Groundwater Extraction via New Wells and Treatment via New Water Treatment Plant for Surface Water Discharge

Alternative GW 3 includes groundwater extraction via new wells and treatment via new water treatment plant for surface water discharge, monitoring, and 5-year Reviews. This alternative would be effective and meets the groundwater-specific IAO. Since the groundwater would be treated to meet surface water discharge requirements and protective levels for NDMA in drinking water, the alternative is protective of human health and the environment. The components for groundwater extraction via new wells and treatment via new water treatment plant for surface water discharge are well-proven and in use in the industry. This alternative will require a specific design study to determine pumping locations, number of wells, and rates, which could result in significant changes to estimated capital and operating costs. Although its relative cost is also high, it is implementable. Alternative GW 3 is retained for detailed analysis.

3.3.3.5. Alternative GW 4: Groundwater Extraction via Butters Row MWSWs and Treatment via New Water Treatment Plant for Surface Water Discharge

Alternative GW 4 includes groundwater extraction via existing Butters Row MWSWs and treatment via new water treatment plant for surface water discharge, monitoring, and 5-year Reviews. Based on historic pumping data, Alternative GW 4 would be effective in managing downgradient migration of higher-concentration groundwater by capturing groundwater that is currently migrating down the Maple Meadow Brook aquifer and therefore meets the groundwater-specific IAO. Since the groundwater would be treated to meet surface water discharge requirements and protective levels for NDMA in drinking water, the alternative is protective of human health and the environment. The components for groundwater extraction via existing Butters Row MWSWs and treatment via new water treatment plant for surface water discharge are well-proven remedial technologies in use in the industry. The cost of rerouting the existing wells would be dependent on the location of the new plant which would subject to Town negotiation and approvals. Although its relative cost is still high, it is implementable. Alternative GW 4 is retained for detailed analysis.

3.3.3.6. Alternative GW 5: Groundwater In-Situ Biological Treatment

Alternative GW 5 includes in-situ biological treatment to bring concentrations of NDMA to protective levels for drinking water, monitoring, and 5-year Reviews. It would be effective if degradation rates are sufficient to significantly reduce or eliminate NDMA concentrations in downgradient groundwater in combination with natural attenuation of other constituents (metals and inorganics subject to reactive transport, sorption and retention by other mechanisms). The components for groundwater in-situ biological treatment have been demonstrated to work at the field scale. However, a laboratory treatability study using site materials—soils and groundwater—to evaluate site-specific biodegradation rates of NDMA and/or pilot scale testing would need to be completed with satisfactory results prior to field scale testing, design and implementation. The cost for this alternative is provided as a provisional cost pending results of a laboratory treatability study and/or pilot scale tests. Pending results of a laboratory treatability study and/or pilot scale testing, this alternative is anticipated to be implementable, with low to moderate cost. Alternative GW 5 is retained for detailed analysis. This alternative and technology requires further evaluation to determine whether it can meet IAOs.

3.3.4 Containment Area Alternatives

This section provides the preliminary screening of Containment Area alternatives.

3.3.4.1. Alternative CA 1

The No action alternative does not include remedial action components to identify and remove soil within the Containment Area that have potential for leaching of constituents to groundwater or to achieve hydraulic isolation of the Containment Area. The No Action alternative provides a baseline for comparison with the other developed alternatives as required by CERCLA and the NCP. Alternative CA 1 is retained for detailed analysis.

3.3.4.2. Alternative CA 2

Alternative CA 2 consists of institutional controls, elimination of the equalization window in the Containment Area Slurry Wall, and installation of a permanent composite cap over the Containment Area to replace the temporary cap installed previously. This alternative would also include long-term O&M and Five-Year Site Reviews. Installation of a permanent cap would contribute to achievement of hydraulic isolation of the Containment Area and more specifically, effectively eliminate any leaching of constituents from soils to groundwater and would meet the IAO. Capping is a well-proven remedial technology and would be protective of human health and the environment. A composite cap is a moderate to high cost alternative compared to other cap designs, but it provides a more effective infiltration barrier that typical cap designs. Alternative CA 2 is retained for detailed analysis.

3.3.4.3. Alternative CA 3

This alternative has been requested by USEPA to address soils in the Containment Area. This alternative is a stand-alone alternative that is independent of Alternative CA 2 (capping). As discussed above, the capping alternative would meet the IAO for the Containment Area without any soil removal.

There is currently no exposure to surface soils beneath the temporary cap. The current institutional control for the property limits future exposure to soils within the Containment Area. Alternative CA 3 therefore consists of identification and removal of soils with potential for leaching of constituents to groundwater. Removal of soils would eliminate potential for leaching and meet the IAO. This alternative is a moderate to high cost alternative compared to installation of a composite cap. The cost is dependent on the volume of soil to be removed. Because potentially contaminated soil would be removed, long-term monitoring and Five-Year Site Reviews would not be required.

As discussed in previous sections of this IAFS, RAMs were completed in 2000 – 2001 to remediate Drum Areas A and B and the Buried Debris Area, which were located within the Containment Area Slurry Wall. During the RAM activities, site investigations were conducted to identify any areas where non-soil materials were present in the subsurface of the property. Investigations were guided by historical records of operations and disposal activities (including historical aerial photographs at the facility). Known drum disposal areas and buried debris areas were identified and delineated by geophysical surveys, magnetometer surveys, test pits and more than 100 soil samples. As a result, Release Abatement Measures were conducted to remove the identified waste materials in Drum Area A, Drum Area B, and the Buried Debris Area. No other waste disposal areas or activities were identified within the boundaries of the Containment Area that was constructed shortly after the RAMs.

The waste materials in the drum areas and the Buried Debris Area were removed from the excavations and characterized for disposal. Some drums and drum parts and contents were overpacked and disposed at licensed facilities as hazardous waste? Other waste materials (including metal debris) and soils identified based on staining and PID screening were segregated and disposed off-site at licensed facilities as non-hazardous solid waste. These materials were sampled and analyzed for waste characterization parameters. Other soils excavated during these activities were stockpiled and sampled for lab analysis to determine their suitability for on property re-use. MassDEP approved submittals that proposed re-use of the stockpiled soils.

Confirmatory sampling of the bottom and sidewalls of the excavations was conducted and the samples submitted for lab analysis to confirm that the concentration objectives of the RAM had been achieved. Some additional excavation and further confirmatory sampling was conducted to fully achieve the objective. The excavations were backfilled with stockpiled soils that had been approved for on-site re-use (industrial/commercial use).

A summary of analytical data for subsurface soil within the Containment Area (undisturbed soils, confirmatory samples, and the soil used to backfill excavations during the RAM activities) is included in **Appendix A.** **Appendix A** also includes a summary of the data for surface soil immediately beneath the temporary cap.

In consideration of this data there is no indication of any waste material (other than cement-stabilized calcium sulfate) remaining in soil within the Containment Area. Further, no human exposure to soils is occurring and a deed restriction precludes future exposure except for grading in preparation for cap installation. With the understanding that a permanent cap will be constructed over the existing temporary cap, a physical barrier will further insure no future exposure to soils. The permanent cap will also eliminate infiltration of precipitation and therefore the potential leaching of constituents from soil to groundwater. Therefore, soil excavation from the Containment Area provides no additional benefit with respect to achieving IAOs and protection of human health and the environment. Finally, shallow groundwater in the Containment Area that could hypothetically be affected by soils is contained by the 1×10^{-8} cm/sec hydraulic barrier.

For the reasons described above, a stand-alone soil removal alternative has not been carried forward for detailed evaluation since it would be redundant to hydraulic isolation by capping.

4.0 ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of alternatives, followed by a comparative analysis of the alternatives.

Remedial alternatives are evaluated with respect to nine CERCLA criteria:

1. Overall protection of human health and the environment
2. Compliance with ARARs.
3. Short-term effectiveness
4. Long term effectiveness and permanence
5. Reduction of toxicity, mobility, or volume through treatment
6. Implementability
7. Cost
8. State acceptance
9. Community acceptance

The remedial alternatives were evaluated for the first seven criteria and then compared with one another to identify their respective strengths and weaknesses. Two criteria, state and community acceptance, were not evaluated because they will be based on comments received and addressed by USEPA during the Record of Decision process which includes the public comment period for the Proposed Plan.

Cost estimates for the remedial alternatives were prepared using USEPA RI/FS guidance (USEPA, 1988b) and FS cost estimating guidance (USEPA, 2000). The cost estimates include capital costs (where appropriate) and operations and maintenance (O&M) costs. Both total cost and present worth costs are provided. An annual discount rate of 2.7 % was applied to calculate present worth.

As discussed in Section 3.0, the development and evaluation of remedial alternatives are presented by media in this IAFS; that is, for LNAPL, DAPL, downgradient groundwater, and Containment Area including soils. CERCLA requires that a no action alternative be included as a baseline for comparison of the remedial alternatives. Because the components and evaluation of the no action alternative would be the same for each media addressed, the no action alternatives for each media addressed in this IAFS are discussed in Section 4.1. The remedial alternatives for LNAPL, DAPL, downgradient groundwater, and Containment Area including soils are presented in

Sections 4.2, 4.3, 4.4, and 4.5 respectively. The comparative analysis of remedial alternatives is presented in Section 4.6.

4.1 Alternatives LNAPL 1, DAPL 1, GW 1, and CA 1: No Action

4.1.1 Components of the No Action Alternatives

The No Action alternative for each media generally does not include additional remedial components to improve the alternatives ability to reduce, control, or eliminate potential risks from exposure to COPCs. Current actions (such as DAPL extraction in the Off-PWD DAPL Pool and LNAPL recovery at Plant B) would be maintained under the No Action Alternatives. The alternatives for these two latter areas are intended to enhance current actions. Plant B would be subject to other possible activities described in the Interim Response Steps Work Plan (MACTEC, 2008), such as the pumping rate reduction test.

4.1.2 Overall Protection of Human Health and the Environment

The No Action Alternatives do not meet the IAOs and are therefore not protective of human health and the environment or do not enhance current source reduction activities. In particular, the No Action alternative for the off-PWD DAPL Pool and Plant B LNAPL do not improve recovery of source materials.

4.1.3 Compliance with ARARs

The No Action Alternatives do not comply with ARARs.

4.1.4 Short-term Effectiveness

The No Action Alternatives are not effective in the short term.

4.1.5 Long-term Effectiveness and Permanence

The No Action Alternatives are not effective in the long-term.

4.1.6 Reduction of Toxicity, Mobility, or Volume through Treatment

The No Action Alternatives do not reduce toxicity, mobility, or volume of COPCs.

4.1.7 Implementability

No measures are implemented as part of the No Action Alternatives.

4.1.8 Cost

The No Action Alternatives have no capital or maintenance costs.

4.2 LNAPL Alternatives

4.2.1 Alternative LNAPL 2: Manual Recovery

4.2.1.1. Components of the Alternative

Alternative LNAPL 2 consists of the following major components:

- Institutional Controls
- Use of Absorbent Socks in Existing Extraction Well
- Use of Absorbent Socks to Recover LNAPL in Additional Monitoring Wells
- Monitoring
- Off-Site Disposal
- 5 Year Site Reviews

Institutional Controls. Alternative LNAPL 2 includes the maintenance of current deed restrictions and institutional controls that prevent ground disturbance or use of groundwater at the Site and fencing that prevents unauthorized entry to the Site.

Manual Recovery from Existing Extraction Well. LNAPL would be recovered by Plant B personnel from existing extraction well IW-11 using a hydrophobic absorbent sock. LNAPL would be stored at the Site in accordance with ARARs.

Manual Recovery from Additional Existing Monitoring Wells LNAPL would be removed from additional wells by hydrophobic absorbent socks. LNAPL would be stored at the Site in accordance with ARARs.

Monitoring. Quarterly groundwater monitoring, including product thickness measurements, would be performed during the time of LNAPL recovery and for a period of time after LNAPL recovery ceases, up to the next 5 year review cycle.

Off-Site Disposal. Recovered LNAPL would be stored at the site and then disposed of in accordance with ARARs at a permitted waste facility.

5-Year Site Reviews. CERCLA requires that any remedial action resulting in contaminants remaining on-site at concentrations above those allowing unlimited exposure and unrestricted use must be reviewed at least every five years. 5-year Site Reviews would be performed in accordance with Comprehensive Five-Year Review Guidance (USEPA, 2001).

4.2.1.2. Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment by preventing receptors' contact with COPCs via institutional controls until IAOs are achieved. LNAPL recovery would remove LNAPL as a source of COPCs to groundwater. Groundwater, in absence of the hydraulic control imposed by current groundwater extraction system, would discharge to East Ditch surface water. Cessation of such pumping would necessitate an evaluation of potential receptor impacts in surface water noting the receptor is a railroad drainage ditch with limited ecological value and function.

4.2.1.3. Compliance with ARARs

This alternative complies with ARARs. It does not include technologies that would impact wetlands, aquatic ecosystems, or sensitive species. The recovery of LNAPL is not based on attainment of media-specific concentrations of specific contaminants or a PRG based on chemical-specific ARARs. This alternative complies with action-specific ARARs by disposing of recovered LNAPL in accordance with federal and state hazardous waste ARARs.

4.2.1.4. Short-term Effectiveness

This alternative is effective in the short-term, since its meet the IAO to enhance LNAPL recovery during the time of construction or implementation.

4.2.1.5. Long-term Effectiveness and Permanence

This alternative also meets the IAO to enhance LNAPL recovery in the long-term. Once LNAPL is removed to the extent practicable, the residual LNAPL phase will largely be immobile. The time expected to remove LNAPL is dependent on the volume of LNAPL present beneath the Plant B foundation, it's thickness and distribution which are unknown. The assumed time frame for costing purposes is 10 years.

4.2.1.6. Reduction of Toxicity, Mobility, or Volume through Treatment

LNAPL has been identified as a source of dissolved-phase COPCs to underlying groundwater. This alternative will reduce the mobility and volume of LNAPL at the Site (through removal, not treatment). This alternative will also reduce the future toxicity of groundwater by removing mobile LNAPL fraction as source of dissolved-phase COPCs. The remaining immobile fraction will remain as a source of dissolved phase constituents, which with time will age and become increasingly depleted in dissolved phase constituents as they are lost from the NAPL through partitioning.

4.2.1.7. Implementability

This alternative is straightforward to implement. It would require a minor workplan amendment to document the LNAPL recovery procedures and personnel to perform the recovery. Minimal additional materials would be required.

4.2.1.8. Cost

The cost for this alternative is presented in **Table 4.2-1**. Capital costs for LNAPL 2 include development of an LNAPL recovery and monitoring workplan addendum. Annual costs include manual LNAPL recovery and monitoring, LNAPL disposal, and status reports. Based on an average removal rate of 0.75 gallons per year, it is estimated to take 30 years to remove LNAPL to the extent practicable. Five additional years of groundwater monitoring were assumed for costing to confirm the absence of LNAPL. The total cost of LNAPL 2 is estimated to be $25,000 with a total present worth of $22,000. The assumed time frame for costing purposes is 10 years.

4.2.2 Alternative LNAPL 3: Continual Mechanical Recovery

4.2.2.1. Components of the Alternative

Alternative LNAPL 3 consists of the following major components:

- Institutional Controls
- Continual Mechanical Recovery
- Monitoring
- Off-Site Disposal
- 5 Year Site Reviews

Institutional Controls. Alternative LNAPL 2 includes the maintenance of institutional controls such as deed restrictions that prevent ground disturbance or use of groundwater at the Site and fencing, which prevents unauthorized access to the Site.

Continual Mechanical Recovery. Three new recovery wells would be installed and fitted with automated skimmers. The skimmers contain hydrophobic/oleophilic filters that allow LNAPL to collect inside the skimmer without also entraining water. The skimmers also contain pumps that are actuated by a centralized controller to periodically pump the collected LNAPL to a drum or other central collection point. The skimmers' elevations fluctuate with the water table to keep the collection port at the product/water interface. This alternative would require access to electricity and compressed air, both of which are already available at Plant B.

Monitoring. Quarterly groundwater monitoring, including product thickness measurements, would be performed during the time of LNAPL recovery and for five years after LNAPL recovery ceases.

Off-Site Disposal. Recovered LNAPL would be stored at the site and then disposed of in accordance with ARARs at a permitted waste facility.

5-Year Site Reviews. CERCLA requires that any remedial action resulting in contaminants remaining on-site at concentrations above those allowing unlimited exposure and unrestricted use must be reviewed at least every five years. 5-year Site Reviews would be performed in accordance with Comprehensive Five-Year Review Guidance (USEPA, 2001).

4.2.2.2. Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment by preventing receptors' contact with COPCs via Institutional Controls and monitoring the thickness of LNAPL during the time of recovery.

4.2.2.3. Compliance with ARARs

This alternative complies with ARARs. It does not include technologies that would impact wetlands, aquatic ecosystems, or sensitive species. The recovery of LNAPL is not based on attainment of media-specific concentrations of specific contaminants or a PRG based on chemical-specific ARARs. This alternative complies with action-specific ARARs by disposing of recovered LNAPL in accordance with federal and state hazardous waste ARARs.

4.2.2.4. Short-term Effectiveness

This alternative is effective in the short-term in that it would meet the IAO to enhance recovery of LNAPL during the time of implementation. LNAPL recovery will be enhanced once construction is complete and the automated skimmers are in use.

4.2.2.5. Long-term Effectiveness and Permanence

This alternative is effective in the long-term. Once the automated skimmers are in use, LNAPL recovery is enhanced. The assumed time frame for costing purposes is 10 years. Once completed, the remedy is permanent; all recoverable LNAPL will have been removed, and five years of quarterly monitoring are included in the remedy to verify the absence of LNAPL.

4.2.2.6. Reduction of Toxicity, Mobility, or Volume through Treatment

LNAPL has been identified as a source of dissolved-phase COPCs to underlying groundwater. This alternative will reduce the mobility and volume of LNAPL at the Site (through removal, not treatment). This alternative will also reduce the future toxicity of groundwater by removing LNAPL as source of dissolved-phase COPCs.

4.2.2.7. Implementability

This alternative is straightforward to implement. Automated skimmers and controllers are well-established remedial technologies that are available from a number of manufacturers in the industry. Implementation of the remedy would require installation of new wells and the installation of the automated skimmers and controllers. Electricity and compressed air, which are necessary to run the skimmers, are already available at Plant B.

4.2.2.8. Cost

The cost for this alternative is presented in **Table 4.2-2**. Capital costs for LNAPL 3 include maintenance of deed restrictions, installation of three new recovery wells with automated skimmers, and installation of the controller. Annual costs include quarterly groundwater monitoring, electricity, LNAPL disposal, and status reports. The assumed time frame for costing purposes is 10 years. Five years of monitoring to ensure the absence of LNAPL are included following the completion of LNAPL recovery. The total cost of Alternative LNAPL 3 is estimated to be $140,000 with a Total Present Worth of $131,000. The remedy is expected to be complete in 10 years.

4.2.3 Alternative LNAPL 4: Multi-Phase Extraction

4.2.3.1. Components of the Alternative

Alternative LNAPL 4 consists of the following major components:

- Institutional Controls
- MPE
- Treatment
- Off-Site Disposal
- Monitoring
- 5 Year Site Reviews

Institutional Controls. Alternative LNAPL 4 includes the maintenance of institutional controls such as deed restrictions that prevent ground disturbance or use of groundwater at the Site and fencing, which prevents unauthorized access to the Site.

MPE. Dedicated pumps are used to remove LNAPL, vapors, and a small amount of groundwater. The MPE system will be skid-mounted and rented from an environmental contractor. The skid-mounted system includes the extraction blower, knockout tank to separate the streams, and vapor treatment, if necessary. Extracted LNAPL would be stored at the Site and disposed of in accordance with ARARs. Extracted groundwater would be treated at the existing Plant B. The skid-mounted system would be rented for up to 12 months. LNAPL recovery through MPE is known to decrease over time, and significant amounts of LNAPL are unlikely to be recovered beyond a 10-month period.

Monitoring. Quarterly groundwater monitoring, including product thickness measurements, would be performed during the time of LNAPL recovery and for five years after LNAPL recovery ceases.

Off-Site Disposal. Recovered LNAPL would be stored at the site and then disposed of in accordance with ARARs at a permitted waste facility.

5-Year Site Reviews. CERCLA requires that any remedial action resulting in contaminants remaining on-site at concentrations above those allowing unlimited exposure and unrestricted use must be reviewed at least every five years. 5-year Site Reviews would be performed in accordance with Comprehensive Five-Year Review Guidance (USEPA, 2001).

4.2.3.2. Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment by preventing receptors' contact with COPCs via Institutional Controls and monitoring the thickness of LNAPL during the time of recovery.

4.2.3.3. Compliance with ARARs

This alternative complies with ARARs. It does not include technologies that would impact wetlands, aquatic ecosystems, or sensitive species. The recovery of LNAPL is not based on attainment of media-specific concentrations of specific contaminants or a PRG based on chemical-specific ARARs. This alternative would comply with chemical-specific ARARs by treating extracted groundwater and vapors prior to discharge. This alternative complies with action-specific ARARs by disposing of recovered LNAPL in accordance with federal and state hazardous waste ARARs.

4.2.3.4. Short-term Effectiveness

This alternative is effective in the short-term in that it would meet the IAO to enhance recovery of LNAPL during the time of implementation. LNAPL recovery will be enhanced once the wells are installed and the MPE system is in use.

4.2.3.5. Long-term Effectiveness and Permanence

This alternative is effective in the long-term. Once the MPE system is in use, LNAPL recovery would be enhanced. It is estimated to take one year to remove mobile LNAPL to the extent practicable. Once completed, the remedy is permanent; recoverable LNAPL will have been removed, and five years of quarterly monitoring are included in the remedy to verify the absence of LNAPL.

4.2.3.6. Reduction of Toxicity, Mobility, or Volume through Treatment

LNAPL has been identified as a source of dissolved-phase COPCs to underlying groundwater. This alternative will reduce the mobility and volume of LNAPL at the Site (through removal, not treatment). This alternative will also reduce the future toxicity of groundwater by removing LNAPL as source of dissolved-phase COPCs.

4.2.3.7. Implementability

This alternative is straightforward to implement. MPE is a well-established remedial technology that is available from a number of vendors in the industry. Implementation of the remedy would require installation of new wells and the rental and operation of the MPE system. Electricity is already available at Plant B.

4.2.3.8. Cost

The cost for this alternative is presented in **Table 4.2-3**. Capital costs for LNAPL 4 include verification of deed restrictions, design of the MPE system, installation of three MPE wells, piping, updates to the RGP, installation and operation of the MPE system, and disposal of LNAPL. Annual costs include quarterly groundwater monitoring as well as status reports. 5-year costs include the 5-Year Review Report and institutional controls verification. The total cost of Alternative LNAPL 4 is estimated to be $195,000 with a Total Present Worth of $190,000. The remedy is expected to be complete in 5 years including five-year reviews.

4.3 DAPL Alternatives

4.3.1 Overview of DAPL Extraction

The DAPL Extraction Pilot Study (AMEC, 2014) and on-going DAPL extraction in the off-PWD DAPL Pool provide the initial basis for development of this alternative.

DAPL density flow considerations. The movement of DAPL is governed by density-driven flow mechanisms which is controlled primarily by the fluid density, viscosity, aquifer permeability and the slope of the aquifer surface, in this case bedrock. DAPL within the pools rests on the bedrock or a parallel basal till surface and is contained within separate, shallow, sloping bedrock depressions, each of which forms a bowl-shaped, sloping aquifer with a low point, or bottom. When fluid is extracted from this low point, the surrounding DAPL, which is denser than the overlying groundwater, flows down the slope towards the extraction point by gravity. For a DAPL removal strategy to be effective, the rate at which the DAPL is removed should not exceed the density-driven flow rate towards the extraction point. Pumping at an excessive rate causes vertical intrusion of higher pH overlying groundwater and over an extended period risks developing conditions that impairs or could lead to failure of the extraction strategy. These include:

- DAPL body becomes disconnected, allowing intrusion of diffuse and overlying groundwater. When the pumping stress is relaxed then re-intrusion of DAPL into areas where it has been displaced will result in mineralization and aquifer clogging;
- Drawdown of the DAPL/diffuse layer interface near the pumping wells with similar detrimental effects;

- Inducing convective flow patterns between DAPL and diffuse layer that would exacerbate existing conditions (e.g., cause contamination to spread over a broader area, increasing concentrations at shallow depths in the aquifer; and
- Advective mixing causing the diffuse layer to thicken.

Based on the results of DAPL extraction from the off-PWD DAPL Pool, it is estimated that 0.25 gpm is the maximum sustainable extraction rate from an individual vertical extraction well at this specific pool. The bedrock slope, which based on available data is shallow, sloping from east to west. During the Pilot Study, extraction rates at and greater than 0.5 gpm caused excessive drawdown, resulting in DAPL dilution and entrainment of overlying groundwater and diffuse material, indicating non-gravimetric DAPL recovery. An extraction rate of 0.25 gpm is sustainable.

The slope of the bedrock surface in the On-Property DAPL pool is also shallow and the pool is limited in size, being roughly semi-circular in shape. It is expected it will have a sustainable extraction rate similar to the Off-PWD pool.

The slope of the bedrock at the Main Street DAPL pool and should be capable of sustaining higher extraction rates for vertical wells, likely in the range of 2 gpm. Extraction wells here would target the several defined low points in the bedrock surface resulting in a multiple well extraction approach.

DAPL extraction wells. The current EW-1 extraction well for the off-PWD DAPL Pool consists of a 6-inch diameter Schedule 40 polyvinyl chloride (PVC) riser pipe with a 5-foot continuous slot (0.010-inch) well screen. The original well concept proposed was a two-foot long screen. The extraction well has a 2-foot sump installed into the top of bedrock, at the request of USEPA for a sediment trap. Above the sump, the well screens the bottom five feet of the DAPL, which sits above the top of rock and a thin basil till zone.

Results of the Pilot Study indicate a shorter screen length is preferable to restrict flow into the well along the bottom of the pool and help isolate the pumping stress vertically from overlying DAPL and overlying groundwater.

The objective for DAPL extraction wells is to extract from the absolute bottom of the DAPL pool, for which vertical wells are best suited. Horizontal wells installed by directional drilling offer an opportunity for longer screen lengths, however due to undulating bedrock topography wells installed by directional bores will invariably end up with screen segments that are above and not situated at the bottom of the pool, or have preferential flow issues due to interception of gravel stringers or horizons. Bedrock undulations and the presence of cobbles and boulders will make the design of a directional bore difficult and hard to predict. These conditions will detract from the objective of extraction from the pool topographic low points. Where there are no physical limitations to identified extraction locations, there is no overriding advantage to consider directional bores over vertical bores.

Olin's interpreted bedrock surface at the Main Street DAPL pool indicates the presence of several deeper conical shaped localized depressions along the bottom of the bedrock, the location and slope of these depressions, could not easily be targeted with a single or multiple horizontal wells. These low points provide excellent target locations for DAPL extraction by vertical wells as their conical shape will promote gravimetric recovery of the DAPL. It is Olin's expectation that sustainable extraction rates at these locations could be on the order of two gallons per minute per well from each vertical well at each of these locations.

4.3.2 Alternative DAPL 2A: DAPL Extraction in the Off-PWD DAPL Pool

4.3.2.1. Components of Alternative DAPL 2A

Alternative DAPL 2A consists of the following major components:

- Institutional Controls
- DAPL Extraction in Off-PWD DAPL Pool
- Operations and Maintenance (O&M)
- Monitoring
- Off-Site Disposal
- 5-Year Site Reviews

Institutional Controls. Deed covenants restricting depth of ground disturbance and prohibiting installation of wells other than for groundwater monitoring would be verified and/or put into place to prevent receptor contact with groundwater or DAPL.

DAPL Extraction in the off-PWD DAPL Pool. DAPL is currently extracted through one extraction well, EW-1, in the Off-PWD DAPL Pool at 0.25 gpm which appears to be the upper rate not exceeding the gravity-driven rate of drainage toward the extraction well.

Olin will install a replacement for this well (EW-1) adjacent to the current well vault and it will be connected to the existing extraction pump. The new extraction well will have a two-foot long screen. Extraction from the current EW-1 will cease and consideration will be given to retrofitting the well as a multilevel observation well within the existing five-foot screened interval, or installing a new multi-level monitoring well. DAPL would continue to be pumped to the Olin Property, where it is stored and then disposed of by a permitted hazardous waste disposal company. A conceptual design layout of the DAPL extraction system is shown on **Figure 4.2-1**.

The current seismic data indicates bedrock slopes east to west under the building situated on the property. Borings are proposed at the northeastern and southeastern corners of the building which would verify the seismically interpreted depth to bedrock for the seismic line located behind the building. If this data indicates bedrock slopes that would warrant an additional extraction well at this end of the pool, an additional well vault would be designed and installed. If an additional extraction well is installed, a multiport well will be installed in close proximity.

The new extraction well pump (if installed) and conveyance systems will be similar to what is installed including - variable speed peristaltic-type pumps discharged through a heat-traced conveyance system comprised of a 1½-inch diameter high density polyethylene (HDPE) carrier pipe contained within a 4-inch diameter PVC containment pipe. When Olin installed the DAPL pilot system, a blank pipe sleeve along with the current DAPL transfer pipe. Depending on where a new well will be installed, piping or DAPL will be routed through exiting clean out vaults and conveyance lines or a new conveyance line will be installed. DAPL would be pumped to the current storage tank where it is off loaded via tanker truck for off-site disposal. For costing purposes, additional pipe runs were assumed to extend to the existing storage tank.

Based on the results of long term DAPL extraction from the off-PWD DAPL Pool and the DAPL density driven flow considerations discussed in Section 4.3.1.1, a combined DAPL extraction rate of 0.5 gpm (0.25 gpm from two wells) is assumed for costing and DAPL removal timeframe calculations. As DAPL levels become progressively lower, the DAPL will become less concentrated, less dense, and, consequently, DAPL gravity drainage rates will diminish. With time, it may become necessary to progressively reduce the rate of DAPL extraction. **Table 4.3-1** summarizes the DAPL Pool volumes and estimated removal times based on estimated extraction rates.

It should be emphasized that 100 percent recovery of DAPL is infeasible; some DAPL will remain as ganglia in a portion of overburden porosity that will not drain freely by gravity, shallow weathered bedrock and bedrock fractures. Residual DAPL is also likely to remain on the bedrock surface in isolated and localized low-points within the DAPL pool.

Operations and Maintenance (O&M). This alternative would require long-term O&M to keep the extraction systems functioning properly and effectively. The scope of the proposed O&M and monitoring is based on the Interim Response Steps Work Plan (MACTEC, 2008), Operations, Maintenance, and Performance Monitoring Plan (AMEC, 2012), and DAPL Extraction Pilot Study Performance Evaluation Report (AMEC, 2014).

- System performance monitoring is assumed to occur monthly and consist of sampling from the multi-level piezometers and induction logging from the monitoring points installed in conjunction with the extraction wells.
- Annual O&M cost assumptions were based on the O&M costs during the DAPL Pilot Test. O&M is assumed to include:
- Routine inspections of the extraction system components, including pumps, pump enclosure vaults, system controls and communication equipment, piping, storage tank(s), and tanker truck loading station(s)
- Periodic evaluation and adjustment of pumping rates
- Pump maintenance and periodic replacement (as necessary)
- Periodic pump heads tubing replacement
- Quarterly O&M inspections

Monitoring. System performance monitoring will be performed at locations near the pumping wells to:

- Evaluate the response of the DAPL/diffuse layer and diffuse layer/overlying groundwater interfaces during pumping,
- Assess trends of monitored parameters in DAPL, diffuse layer, and overlying groundwater, and
- Assess specific chemical characteristics of the extracted DAPL.

Two multilevel piezometers (ML-1 and ML-2) and two induction logging wells (ILW-1 and ILW-2) are currently in place near the existing extraction and are currently used for monitoring progress of DAPL removal at EW-1. In addition, a third multilevel piezometer (MP-2) farther from the extraction well is currently installed to monitor DAPL elevation. After EW-1 is replaced by an adjacent well, consideration will be given to installing a multilevel device in EW-1 or installing an additional multilevel piezometer at an appropriate location.

It is assumed that DAPL extraction system performance monitoring will be performed monthly to bi-monthly during the operation of the DAPL extraction system and that operating conditions and monitoring data will be reported semi-annually.

Off-Site Disposal. Extracted DAPL is currently being transported via tanker truck to two permitted commercial hazardous waste facilities. Cost calculations for Alternative DAPL 2 assume that extracted DAPL will be disposed at the Waste Management deep well injection facility in Vickery Ohio.

USEPA has offered its assistance in identifying alternate DAPL management options; but to date no assistance has been received.

5-Year Site Reviews. CERCLA requires that any remedial action resulting in contaminants remaining on-site at concentrations above those allowing unlimited exposure and unrestricted use must be reviewed at least every five years. 5-year Site Reviews would be performed in accordance with Comprehensive Five-Year Review Guidance (USEPA, 2001).

4.3.2.2. Alternative DAPL 2A Evaluation

This subsection provides an evaluation of the alternative by discussing how the alternative complies with the CERCLA alternative evaluation criteria.

4.3.2.2.1. Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment by removing DAPL and its associated COPCs from the three DAPL pools. Extracted DAPL would be transferred and disposed of in accordance with ARARs.

4.3.2.2.2. Compliance with ARARs

The extraction of DAPL is not based on attainment of media-specific concentrations of specific contaminants or a PRG based on chemical-specific ARARs. This alternative complies with action- and location-specific ARARs. Work in areas with location-specific ARARs will be performed in accordance with those ARARs. Should work be performed in identified wetlands or floodplain areas (installation of piping) the areas disturbed will be minimized and will be restored in accordance with ARARs.

4.3.2.2.3. Short-term Effectiveness

This alternative is effective in the short term in that it will immediately begin to reduce volume of DAPL at OCSS. While DAPL extraction will take approximately 5-10 years to be complete, extraction is currently ongoing in the off-PWD DAPL pool and has been proven an effective remedy through the DAPL Pilot Test. Costing is based on an additional well in year 3 and a five year extraction period.

4.3.2.2.4. Long-term Effectiveness and Permanence

This alternative is effective in the long-term. Extraction will permanently remove DAPL and its associated COPCs. This alternative includes long term O&M and institutional controls to ensure long-term protection of human health and the environment. Some residual DAPL is expected to remain in the weathered bedrock and in localized depressions on the bedrock surface of the DAPL pool. DAPL may also be stranded in the overburden where it is not freely drainable, and precipitation of some DAPL constituents such as iron, sulfate, aluminum, and chromium will result in retention of those constituents.

4.3.2.2.5. Reduction of Toxicity, Mobility, or Volume Through Treatment

DAPL is a source of COPCs to overlying groundwater and bedrock groundwater. This alternative reduces the volume of DAPL through extraction and disposal. DAPL and its associated COPCs will be permanently removed from the site and disposed of in accordance with RCRA hazardous waste standards.

4.3.2.2.6. Implementability

This alternative is straightforward to implement. The technologies necessary are available and well-proven for use. The components of the proposed alternative are already in place and operational.

4.3.2.2.7. Cost

The cost for this alternative is presented in **Table 4.3-2**. Capital costs include an extraction well to replace EW-1, borings to confirm existing geophysical data and to determine the possibility of a second extraction well, and the cost of the second extraction well (assuming it will be recommended).

Costing is based on an additional well installed in year 3 and a five-year extraction period.

Annual cost estimates include electricity and fuel costs as well as O&M, performance monitoring, and DAPL transport and disposal. Based on the estimated volume of the Off-PWD DAPL Pool, the extraction system is expected to operate for a total of 5 years. The total cost of Alternative DAPL 2A is $1,036,000 and the present worth of Alternative DAPL 2A is $1,012,000.

4.3.3 Alternative DAPL 2B: DAPL Extraction in the On-Property DAPL Pool

4.3.3.1. Components of Alternative DAPL 2B

Alternative DAPL 2B consists of the following major components:

- Institutional Controls
- DAPL Extraction in On-Property DAPL Pool
- Operations and Maintenance (O&M)
- Monitoring
- Off-Site Disposal
- 5-Year Site Reviews

Institutional Controls. Deed covenants restricting depth of ground disturbance and prohibiting installation of wells other than for groundwater monitoring would be verified and/or put into place to prevent receptor contact with groundwater or DAPL.

DAPL Extraction in the On-Property DAPL Pool. A DAPL extraction system similar to that in the Off-PWD DAPL Pool would be installed in the On-Property DAPL Pool. A conceptual design layout of the DAPL extraction system is shown on **Figure 4.2-1**.

The extraction well proposed for the On-Property DAPL Pool would be constructed similarly to EW-1, except with a 2-foot screen length.

For the purpose of this FS, vertical well construction is considered the most appropriate method. Based on soil borings and excavation during the slurry wall at the Containment Area the bottom of the till has numerous boulders. These conditions would make installation of a horizontal well problematic and uncertain as to what interval it is extracting DAPL from. A directional bore offers no advantage at this location. Vertical wells provide more dependable and predictable contact because the screen is designed with precision to intercept the target material. Vertical wells also provide more certainty with regard to the elevation and strata that are the focus of the extraction and allow for extraction from the system's lowest point.

One induction logging well would be constructed near the new extraction well in the same manner as existing induction logging wells ILW-1 and ILW-2 in the Off-PWD DAPL Pool.

One multi-level piezometers would also be constructed in the same manner as existing multi-level piezometers ML-1 and ML-2 in the Off-PWD DAPL Pool: with the Model 401 Waterloo System with single stem PVC sampling ports from Solinst™. The piezometers would be constructed within a temporarily-cased 6-inch diameter borehole completed via rotosonic drilling methods.

The extraction pump will be a variable speed peristaltic-type to protect the pump mechanics from contact with DAPL. The pump rotation speed and discharge would be regulated by a variable frequency drive set and monitored by the control panel located adjacent to the DAPL storage tank at the Olin Property. The discharge pipe would be an equivalent design as installed at the Off-PWD pool.

Table 4.3-1 summarizes the DAPL Pool volumes and estimated removal times based on estimated extraction rates of 0.25 gpm. Costing is based on this timeframe.

Operations and Maintenance (O&M). This alternative would require long-term O&M to keep the extraction systems functioning properly and effectively. The scope of the proposed O&M and monitoring is based on the Interim Response Steps Work Plan (MACTEC, 2008), Operations, Maintenance, and Performance Monitoring Plan (AMEC, 2012), and DAPL Extraction Pilot Study Performance Evaluation Report (AMEC, 2014). The O&M requirements would be the same as described in Alternative DAPL 2A.

Off-Site Disposal. Extracted DAPL is currently being transported via tanker truck to two permitted commercial hazardous waste facilities. Cost calculations for Alternative DAPL 2B assume that extracted DAPL will be disposed at the Waste Management deep well injection facility in Vickery Ohio.

5-Year Site Reviews. CERCLA requires that any remedial action resulting in contaminants remaining on-site at concentrations above those allowing unlimited exposure and unrestricted use must be reviewed at least every five years. 5-year Site Reviews would be performed in accordance with Comprehensive Five-Year Review Guidance (USEPA, 2001).

4.3.3.2. Alternative DAPL 2B Evaluation

This subsection provides an evaluation of the alternative by discussing how the alternative complies with the CERCLA alternative evaluation criteria.

4.3.3.2.1. Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment by removing DAPL and its associated COPCs. Extracted DAPL would be transferred and disposed of in accordance with chemical- and action-specific ARARs. Work in areas with location-specific ARARs will be performed in accordance with those ARARs.

4.3.3.2.2. Compliance with ARARs

The extraction of DAPL is not based on attainment of media-specific concentrations of specific contaminants or a PRG based on chemical-specific ARARs. This alternative complies with action- and location-specific ARARs. Should work be performed in identified wetlands or floodplain areas (installation of piping) the areas disturbed will be minimized and will be restored in accordance with ARARs.

4.3.3.2.3. Short-term Effectiveness

This alternative is effective in the short term in that it will reduce the volume of DAPL at OCSS during the time of implementation.

4.3.3.2.4. Long-term Effectiveness and Permanence

This alternative is effective in the long-term. Extraction will permanently remove DAPL and its associated COCs. This alternative includes long term O&M and institutional controls to ensure long-term protection of human health and the environment. Some residual DAPL is expected to remain in the weathered bedrock and in localized depressions on the bedrock surface of the DAPL pool. DAPL may also be stranded in the overburden where it is not freely drainable, and precipitation of some DAPL constituents such as iron, sulfate, aluminum, and chromium will result in retention of those constituents.

4.3.3.2.5. Reduction of Toxicity, Mobility, or Volume Through Treatment

DAPL is toxic and is a source of COCs to overlying groundwater. This alternative reduces the volume of DAPL through extraction and disposal. DAPL and its associated COCs will be permanently removed from the site and disposed of in accordance with RCRA hazardous waste standards.

4.3.3.2.6. Implementability

This alternative is straightforward to implement. The technologies necessary are available and well-proven for use. Implementation of the remedy would require installation of new wells and conveyance piping to transfer the extracted DAPL to the existing dual wall storage tank. Electricity and other utilities are currently available on-Site.

4.3.3.2.7. Cost

The cost for this alternative is presented in **Table 4.3-3**. The capital cost estimate includes design and installation of one extraction well, associated piping, one multi-level piezometers, and one induction logging well. The capital cost also includes underground heat-traced conveyance piping to transfer DAPL to the DAPL storage tank while awaiting disposal.

Annual cost estimates include electricity and fuel costs as well as O&M, performance monitoring, and DAPL transport and disposal. Based on the estimated volume of the Off-PWD DAPL Pool, the extraction system is expected to operate for a total of 5 years. Five-year costs include 5-Year Review reports and verification/maintenance of institutional controls. The total cost of Alternative DAPL 2B is $2,818,000 with a present worth of $2,487,000.

4.3.4 Alternative DAPL 2C: DAPL Extraction in the Main Street DAPL Pool

4.3.4.1. Components of Alternative DAPL 2C

Alternative DAPL 2C consists of the following major components:

- Institutional Controls
- DAPL Extraction in Main Street DAPL Pool
- Operations and Maintenance (O&M)
- Monitoring
- Off-Site Disposal
- 5-Year Site Reviews

Institutional Controls. Deed covenants restricting depth of ground disturbance and prohibiting installation of wells other than for groundwater monitoring would be verified and/or put into place to prevent receptor contact with groundwater or DAPL.

DAPL Extraction in the Main Street DAPL Pool. A DAPL extraction system similar to that in the Off-PWD DAPL Pool would be installed in the Main Street DAPL Pool. The DAPL extraction system for the Main Street DAPL Pool would use three extraction wells as opposed to a single extraction well. A conceptual design of the DAPL extraction system layout is shown on **Figure 4.2-1**.

The proposed extraction wells be constructed similarly to EW-1, except with a 2-foot screen length. As discussed previously, the nature of the localized depressions that will be targeted for extraction well installations are accessible by vertical well locations and therefore directional drilling offers no advantages. The steeper slopes associated with the Main Street DAPL pool should allow for higher sustainable extraction rates. If 2 gpm is sustainable rate for each vertical well, the DAPL pool could be largely depleted within five years of system operation. Olin believes this is a sufficiently aggressive extraction approach for the Main Street DAPL pool.

One induction logging well and one multilevel piezometer would be constructed near each new extraction well in the same manner as existing multilevel and induction logging wells at the Off-PWD DAPL Pool. Three additional ML/ILW pairs would be distributed throughout the DAPL pool to monitor DAPL extraction progress across the pool.

Extraction pumps are assumed to be electrically-operated variable speed peristaltic-type regulated by a variable frequency drive set and monitored by a control panel located adjacent to the DAPL storage tank at the Olin Property.

The extraction pumps would discharge through a dual wall heat-traced conveyance system comprised of a 1½-inch diameter high density polyethylene (HDPE) carrier pipe contained within a 4-inch diameter PVC containment pipe. The carrier pipe would run in an underground utility trench from the pump enclosure vaults through a series of Inspection/Cleanout (I/CO) structures to the 51 Olin property. From there, the carrier pipe would terminate at a collection point for discharge to a transport vehicle for off-site disposal. For costing purposes, pipe runs were assumed to extend to the existing storage tank area. Implementation of the Main Street DAPL pool extraction would require installation of two additional DAPL storage tanks.

Based on the results of long term DAPL extraction from the off-PWD DAPL Pool and the DAPL density driven flow considerations discussed in Section 4.3.1.1, a DAPL extraction rate of 2.0 gpm per well is assumed for costing and timeframe calculations. As DAPL levels become progressively lower, the DAPL will become less concentrated, less dense, and, consequently, DAPL gravity drainage rates will likely diminish toward the end of the extraction period. With time, it may become necessary to progressively reduce the rate of DAPL extraction. **Table 4.3-1** summarizes the DAPL Pool volumes and estimated removal times based on estimated extraction rates.

Complete recovery of DAPL is considered infeasible. Some DAPL will remain as ganglia in a portion of overburden porosity and with shallow weathered bedrock. Residual DAPL is also likely to remain on the bedrock surface in localized low-points within the DAPL pool.

Operations and Maintenance (O&M). This alternative would require long-term O&M to keep the extraction systems functioning properly and effectively. The scope of the system operation, maintenance, monitoring, and DAPL management is assumed to be the same as other DAPL alternatives discussed previously.

Six multilevel piezometers and six induction logging wells constructed as described above would be used for these monitoring activities. It is assumed that DAPL extraction system performance monitoring would be performed monthly during the operation of the DAPL extraction system and that operating conditions and monitoring data will continue to be reported semi-annually.

Off-Site Disposal. Extracted DAPL is currently being transported via tanker truck to two permitted commercial hazardous waste facilities. Cost calculations for Alternative DAPL 2C assume that extracted DAPL will be disposed at the Waste Management deep well injection facility in Vickery Ohio.

5-Year Site Reviews. CERCLA requires that any remedial action resulting in contaminants remaining on-site at concentrations above those allowing unlimited exposure and unrestricted use must be reviewed at least every five years. 5-year Site Reviews would be performed in accordance with Comprehensive Five-Year Review Guidance (USEPA, 2001).

4.3.4.2. Alternative DAPL 2C Evaluation

This subsection provides an evaluation of the alternative by discussing how the alternative complies with the CERCLA alternative evaluation criteria.

4.3.4.2.1. Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment by removing DAPL and its associated COPCs. Extracted DAPL would be transferred and disposed of in accordance with chemical- and action-specific ARARs. Work in areas with location-specific ARARs will be performed in accordance with those ARARs.

4.3.4.2.2. Compliance with ARARs

The extraction of DAPL is not based on attainment of media-specific concentrations of specific contaminants or a PRG based on chemical-specific ARARs. This alternative complies with action- and location-specific ARARs. Should work be performed in identified wetlands or floodplain areas (installation of piping) the areas disturbed will be minimized and will be restored in accordance with ARARs.

4.3.4.2.3. Short-term Effectiveness

This alternative is effective in the short term in that it will reduce the volume of DAPL at OCSS during the time of implementation.

4.3.4.2.4. Long-term Effectiveness and Permanence

This alternative is effective in the long-term. Extraction will permanently remove DAPL and its associated COPCs. This alternative includes long term O&M and institutional controls to ensure long-term protection of human health and the environment. Some residual DAPL is expected to remain in the weathered bedrock and in localized depressions on the bedrock surface of the DAPL pool. Precipitation of some DAPL constituents such as iron, sulfate, aluminum, and chromium will result in retention of those constituents in the aquifer matrix.

4.3.4.2.5. Reduction of Toxicity, Mobility, or Volume Through Treatment

DAPL is toxic and is a source of COPCs to overburden and bedrock groundwater. This alternative reduces the volume of DAPL through extraction and disposal. DAPL and its associated COPCs will be permanently removed from the site and disposed of in accordance with RCRA hazardous waste standards.

4.3.4.2.6. Implementability

This alternative is straightforward to implement. The technologies necessary are available and well-proven for use. Implementation of the remedy would require installation of new wells and conveyance piping to transfer the extracted DAPL to new dual wall storage tanks. Electricity and other utilities are currently available.

4.3.4.2.7. Cost

The cost for this alternative is presented in **Table 4.3-4**. The capital cost estimate includes geophysical investigation, design and installation of three extraction wells, associated piping and storage tank, six multi-level piezometers, and six induction logging wells. The capital cost also includes underground heat-traced conveyance piping to transfer DAPL to the Site property line, and above-grade piping to transfer DAPL to two new storage tanks while awaiting disposal.

Annual cost estimates include electricity and fuel costs as well as O&M, performance monitoring, and DAPL transport and disposal. Based on the estimated volume of the Off-PWD DAPL Pool, the extraction system is expected to operate for a total of 5 years. Five-year periodic costs include 5-Year Review reports and verification/maintenance of institutional controls. The total cost for Alternative DAPL 2C is $28,272,000 with a total present worth of $26,091,000.

4.4 Groundwater Alternatives

4.4.1 Alternative GW 2A: Groundwater Extraction via MWSWs with Treatment for Potable Use by Additions to Municipal Water Treatment Plant

4.4.1.1. Components of Alternative GW 2A

Alternative GW 2A consists of the following major components:

- Institutional Controls
- Groundwater Extraction via MWSWs (requires Town acceptance)
- Treatment Additions to Municipal Water Treatment Plant
- Treated Potable Water Monitoring
- Groundwater Monitoring
- 5 Year Site Reviews

Institutional Controls. Deed covenants prohibiting installation of wells other than for groundwater monitoring within the boundaries of groundwater impact would be put into place and verified to prevent receptor contact with groundwater.

Groundwater Extraction via MWSWs. In this alternative, two Wilmington MWSWs that are currently shut down, Butters Row Number 1 and Number 2 (see **Figure 1.4-2**) would be re-activated. Water extracted from these wells would be treated at the municipal water plant, which would be upgraded.

Treatment Additions to Municipal Plant. Water extracted by the reactivated municipal wells would be treated at the municipal plant (which would be upgraded to include UV oxidation units to treat NDMA) so that COCs meet ARARs-based target concentrations and/or target concentrations based on achievement of CERCLA risk limits. Redundant (back-up) UV oxidation units would be installed to ensure reliability and continuity of treatment. Should one unit require maintenance the other unit is immediately available and on-line. The water would be treated to meet ARARs-based target concentrations and/or target concentrations based on achievement of CERCLA risk limits and would then be potable and available for municipal use.

It is important to note that this alternative is viable only if the it achieved public acceptance and the Town elects to re-activate the former MWSWs. If the Town wells are not reactivated, this alternative would not be implementable and would need to be reevaluated.

Groundwater monitoring. Concentrations of COCs in groundwater would be monitored by sampling of existing monitoring wells to demonstrate groundwater capture and management of migration.

Treated potable water monitoring. Concentrations of COCs in the treated potable water supplied to the distribution system by the treatment plant to insure the continued protection of human health.

Five-year site reviews. CERCLA requires that any remedial action resulting in contaminants remaining on-site at concentrations above those allowing unlimited exposure and unrestricted use must be reviewed at least every five years. 5-year Site Reviews would be performed in accordance with Comprehensive Five-Year Review Guidance (USEPA, 2001).

4.4.1.2. Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment by preventing receptor contact with COCs in groundwater through institutional controls and by extracting groundwater for treatment. Extracted groundwater would be treated to meet to meet ARARs-based target concentrations and/or target concentrations based on achievement of CERCLA risk limits. Treated potable water concentrations would be monitored to verify water quality.

4.4.1.3. Compliance with ARARs

This alternative complies with ARARs. Extracted groundwater would be treated to meet chemical-specific ARARs and CERCLA risk limits. Treated potable water monitoring and treatment additions to the municipal plant would be performed in accordance with location- and action-specific ARARs.

4.4.1.4. Short-term Effectiveness

This alternative is effective in the short term in that it will meet the groundwater-specific IAO (management of downgradient migration of higher-concentration groundwater) and also be protective of public health during implementation. This alternative will prevent exposure via potable use to COCs at concentrations exceeding drinking water ARARs and those concentrations associated with cancer risk of 1×10^{-4} and/or HI greater than 1 immediately through both institutional controls and treatment of groundwater.

During the historical pumping of Butters Row 1 and Butters Row 2, there was documented draw down associated with the wells and groundwater elevation data indicated a gradient and flow from the Maple Meadow Brook wetland area into these operating wells. The groundwater elevation contours indicated influence of each of these wells extended 600 to 800 feet and the contours shown on Plate 2-3 of the Supplemental Phase II report (Smith, 1997) indicates that capture of impacted groundwater by the Butters Row wells is achievable. Capture of impacted groundwater will be demonstrated and monitored by sampling and analysis of samples from existing monitoring wells in the vicinity and downgradient of the two water supply wells.

4.4.1.5. Long-term Effectiveness and Permanence

This alternative is effective in the long-term since it will meet the objective of controlling downgradient migration of higher-concentration groundwater throughout the duration of its implementation. Once constructed, the additions to the treatment plant will also provide potable water for use by the Town and puts the MMB aquifer back into productive use. Treatment of extracted water would continue until the COCs in groundwater in the aquifer meet ARARs-based target levels and those levels associated with cancer risk and HI that meet CERCLA limits. Maintenance of the UV-oxidation units will be required for the duration of their use. O&M of these systems has been included in cost estimating. This interim action could become a component of the permanent remedy. O&M of the municipal treatment additions would continue throughout implementation of the alternative. Groundwater and treated potable water monitoring would be performed to demonstrate continued compliance with the management of migration objective and the continued protection of public health.

4.4.1.6. Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative reduces the toxicity, mobility and volume of contaminated groundwater through extraction and treatment.

4.4.1.7. Implementability

This alternative is straightforward to implement. The technologies necessary are available and well-proven for use. Additional space would need to be identified for construction of the treatment additions to the municipal plant. It is practically feasible to add treatment trains to the existing system.

4.4.1.8. Cost

The cost for this alternative is presented in **Table 4.4-1**. The capital cost estimate includes UV oxidation units at the municipal plant. Annual cost estimates include monitoring costs, treatment additions to the municipal plant, and 5-year site reviews. The total cost for Alternative GW 2A is $42,344,000 with a total present worth of $17,330,000.

4.4.2 Alternative GW 2B: Groundwater Extraction via MWSWs with Treatment for Surface Water Discharge by Additions to Municipal Water Treatment Plant

4.4.2.1. Components of Alternative GW 2B

Alternative GW 2B consists of the following major components:

- Institutional Controls
- Groundwater Extraction via MWSWs (if the Town agrees)
- Treatment Additions to Municipal Water Treatment Plant
- Groundwater Monitoring
- Treated Water Discharge Monitoring
- 5 Year Site Reviews

Institutional Controls. Deed covenants restricting depth of ground disturbance and prohibiting installation of wells other than for groundwater monitoring would be verified and/or put into place to prevent receptor contact with groundwater.

Groundwater Extraction via MWSWs. In this alternative, two Wilmington MWSWs that are currently shut down, Butters Row Number 1 and Number 2 (see **Figure 1.4-2**) would be re-activated. Water extracted from these wells would be treated at the municipal water plant, which would be upgraded.

Treatment Additions to Municipal Plant. Water extracted by the reactivated municipal wells would be treated at the municipal plant (which would be upgraded to include UV oxidation units to treat NDMA) so that COCs meet discharge permit limits and drinking water quality standards. Redundant (back-up) UV oxidation units would be installed to ensure continuity of treatment. The water would be treated and would then be discharged to surface water.

This alternative is viable only if the Town agrees to re-activate the former MWSWs. If the Town wells are not reactivated, this alternative would not be implementable and need to be reevaluated.

Groundwater monitoring. Concentrations of COCs in groundwater would be monitored using existing monitoring wells through sampling and analysis to demonstrate continued management of migration.

Treated water discharge monitoring. Concentrations of COCs in the treated water discharge will be conducted to document continued protection of public health and the environment.

Five-year site reviews. Five-year site reviews would be performed in the same manner as described in Alternative GW 2A.

4.4.2.2. Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment by preventing receptor contact with COCs in groundwater through institutional controls and by extracting groundwater for treatment and discharging to surface water. Extracted groundwater would be treated to meet surface water discharge requirements and drinking water ARARs-based target levels and target levels based on CERCLA risk limits. NDMA would be treated to a level suitable for drinking water prior to being discharged to surface water. Treated groundwater effluent concentrations would be monitored to demonstrate compliance with discharge permit requirements and document continued protection of human health and the environment.

4.4.2.3. Compliance with ARARs

This alternative complies with ARARs. Extracted groundwater would be treated (including UV-oxidation) to meet chemical-specific ARARs (permit discharge requirements). Groundwater monitoring and treatment additions to the municipal plant would be performed in accordance with location- and action-specific ARARs.

4.4.2.4. Short-term Effectiveness

This alternative is effective in the short term in that it will meet the groundwater-specific IAO (management of downgradient migration of higher-concentration groundwater) and also be protective of public health during implementation. This alternative will prevent exposure via potable use to COCs at concentrations exceeding drinking water ARARs and those concentrations associated with cancer risk of 1 x 10^{-4} and/or HI greater than 1 immediately through institutional controls. and treatment of groundwater. This alternative will also be protective of the environment by meeting treated groundwater discharge permit limits.

4.4.2.5. Long-term Effectiveness and Permanence

This alternative is effective in the long-term since it will meet the objective of controlling downgradient migration of higher-concentration groundwater. Once constructed, the additions to the treatment plant will provide treatment of the extracted groundwater prior to its discharge to surface water. Maintenance of the UV-oxidation units will be required for the duration of their use. O&M of these systems has been included in cost estimating. This interim action could become a component of the permanent remedy. O&M of the municipal treatment additions would continue throughout implementation of the alternative. Groundwater and treated water discharge monitoring would be performed to demonstrate continued compliance with the management of migration objective and the continued protection of public health and the environment.

4.4.2.6. Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative reduces the toxicity, and volume of contaminated groundwater through extraction and treatment. Operation of the MWSWs would control downgradient migration of the groundwater plume, reducing mobility.

4.4.2.7. Implementability

This alternative is straightforward to implement. The technologies necessary are available and well-proven for use. Additional space would need to be identified for construction of the treatment additions to the municipal plant. It is practically feasible to add treatment trains to the existing system.

4.4.2.8. Cost

The cost for this alternative is presented in **Table 4.4-2**. The capital cost estimate includes UV oxidation units at the municipal plant. Annual cost estimates include monitoring costs, treatment additions to the municipal plant, and 5-year site reviews. The total cost for Alternative GW 2B is $55,517,000 with a total present worth of $23,565,000.

4.4.3 Alternative GW 3: Groundwater Extraction via New Wells and Treatment via New Water Treatment Plant for Surface Water Discharge

4.4.3.1. Components of Alternative GW 3

Alternative GW 3 consists of the following major components:

- Institutional Controls
- Groundwater Extraction via New Wells
- Groundwater Treatment by New Treatment Plant
- Treated Water Discharge Monitoring
- Groundwater Monitoring
- 5 Year Site Reviews

Institutional Controls. Deed covenants prohibiting installation of wells other than for groundwater monitoring / extraction would put into place and verified to prevent receptor contact with groundwater.

Groundwater Extraction via New Extraction Wells. In this alternative, a new groundwater extraction well(s) would be installed near GW-65S. Water extracted from this well(s) would be treated at a new treatment plant, which would be constructed near Butters Row to treat this extracted groundwater.

New Water Treatment Plant. Water extracted by the new extraction well(s) would be treated at a new water treatment plant, which would be constructed near Butters Row and would include UV oxidation units to treat NDMA. Redundant (back-up) UV oxidation units would be installed to ensure continuity of treatment. The water would be treated to meet NPDES surface water discharge or equivalent requirements and would then be discharged to surface water.

Concentrations of COCs in groundwater would be monitored using existing monitoring wells through sampling and analysis to demonstrate continued management of migration.

Treated water discharge monitoring. Concentrations of COCs in the treated water discharge will be conducted to document continued protection of public health and the environment.

Groundwater monitoring. Concentrations of COCs in groundwater would be monitored using existing monitoring wells through sampling and analysis to demonstrate continued management of migration.

Treated water discharge monitoring. Concentrations of COCs in the treated water discharge will be conducted to document continued protection of public health and the environment.

Five-year site reviews. Five-year site reviews would be performed in the same manner as described in Alternative GW 2A.

4.4.3.2. Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment by preventing receptor contact with COCs in groundwater through institutional controls and by extracting groundwater for treatment. Extracted groundwater would be treated to meet NPDES discharge requirements so that it can be discharged to surface water. Groundwater concentrations would be monitored to verify that risk stays below threshold values.

4.4.3.3. Compliance with ARARs

This alternative complies with ARARs. Extracted groundwater would be treated via UV-oxidation to meet chemical-specific ARARs. Groundwater monitoring and treatment processes in the new water treatment plant would be in accordance with location- and action-specific ARARs.

4.4.3.4. Short-term Effectiveness

This alternative is effective in the short term in that it will meet the groundwater-specific IAO (management of downgradient migration of higher-concentration groundwater) and also be protective of public health during implementation. This alternative will prevent exposure via potable use to COCs at concentrations exceeding drinking water ARARs and those concentrations associated with cancer risk of 1 x 10-4 and/or HI greater than 1 immediately through institutional controls and treatment of groundwater. This alternative will also be protective of the environment by meeting treated groundwater discharge permit limits.

4.4.3.5. Long-term Effectiveness and Permanence

This alternative is effective in the long-term since it will meet the objective of controlling downgradient migration of higher-concentration groundwater. Once constructed, the treatment plant will provide treatment of the extracted groundwater prior to its discharge to surface water. Maintenance of the included UV-oxidation units will be required for the duration of their use. O&M of these systems has been included in cost estimating. This interim action could become a component of the permanent remedy. Groundwater and treated water discharge monitoring would be performed to demonstrate continued compliance with the management of migration objective and the continued protection of public health and the environment.

4.4.3.6. Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative reduces the toxicity, and volume of contaminated groundwater through extraction and treatment. In addition, operation of the new extraction well(s) will likely result in control of the groundwater plume, reducing mobility.

4.4.3.7. Implementability

This alternative is straightforward to implement. The technologies necessary are available and well-proven for use. Space would need to be identified for construction of the new treatment plant. It is practically feasible to construct a new building with pretreatment and UV-oxidation units.

4.4.3.8. Cost

The cost for this alternative is presented in **Table 4.4-3**. The capital cost estimate includes installation of a new extraction well(s) and construction of a new treatment plant with pretreatment and UV-oxidation for treatment of the extracted groundwater. Annual cost estimates include monitoring costs, O&M of the groundwater extraction and treatment systems, and 5-year site reviews. The total cost for Alternative GW 3 is $32,710,000 with a total present worth of $13,503,000.

4.4.4 Alternative GW 4: Groundwater Extraction via Butters Row MWSWs and Treatment via New Water Treatment Plant for Surface Water Discharge

4.4.4.1. Components of Alternative GW 4

Alternative GW 4 consists of the following major components:

- Institutional Controls
- Groundwater Extraction via existing Butters Row MWSWs 1 and 2
- Groundwater Treatment by New Treatment Plant
- Groundwater Monitoring
- Treated Discharge Water Monitoring
- 5 Year Site Reviews

Institutional Controls. Deed covenants restricting depth of ground disturbance and prohibiting installation of wells other than for groundwater monitoring would be verified and/or put into place to prevent receptor contact with groundwater.

Groundwater Extraction via MWSWs. In this alternative, two Wilmington MWSWs that are currently shut down, Butters Row Number 1 and Number 2 (see **Figure 1.4-2**) would be re-activated. Water extracted from these wells would be treated at a new water treatment plant. This would allow the existing Butters Row Water Treatment plant to continue treating water supplied by the Shawsheen well for distribution.

New Water Treatment Plant. Water extracted by the MWSWs Butters Row 1 and 2 would be piped to the new water treatment plant, which would be constructed near Butters Row and would include UV oxidation units to treat NDMA. Redundant (back-up) UV oxidation units would be installed to ensure continuity of treatment. The water would be treated to meet NPDES surface water discharge requirements and would then be discharged to surface water.

Groundwater monitoring. Concentrations of COCs in groundwater would be monitored using existing monitoring wells through sampling and analysis to demonstrate continued management of migration.

Treated Discharge Water Monitoring. Concentrations of COCs in the treated water discharge will be conducted to document continued protection of public health and the environment.

Five-year site reviews. Five-year site reviews would be performed in the same manner as described in Alternative GW 2A.

4.4.4.2. Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment by preventing receptor contact with COCs in groundwater through institutional controls and by extracting groundwater for treatment. Extracted groundwater would be treated to meet NPDES discharge requirements so that it can be discharged to surface water. Groundwater concentrations would be monitored to demonstrate compliance with discharge permit limits and continued protection of human health and the environment.

4.4.4.3. Compliance with ARARs

This alternative complies with ARARs. Extracted groundwater would be treated via UV-oxidation to meet chemical-specific ARARs. Groundwater monitoring and treatment processes in the new water treatment plant would be in accordance with location- and action-specific ARARs.

4.4.4.4. Short-term Effectiveness

This alternative is effective in the short term in that it will meet the groundwater-specific IAO (management of downgradient migration of higher-concentration groundwater) and also be protective of public health during implementation. This alternative will prevent exposure via potable use to COCs at concentrations exceeding drinking water ARARs and those concentrations associated with cancer risk of 1×10^{-4} and/or HI greater than 1 immediately through institutional controls and treatment of groundwater. This alternative will also be protective of the environment by meeting treated groundwater discharge permit limits.

4.4.4.5. Long-term Effectiveness and Permanence

This alternative is effective in the long-term since it will meet the objective of controlling downgradient migration of higher-concentration groundwater. Once constructed, the treatment plant will provide treatment of the extracted groundwater prior to its discharge to surface water. Maintenance of the included UV-oxidation units will be required for the duration of their use. O&M of these systems has been included in cost estimating. This interim action could become a component of the permanent remedy. Groundwater and treated water discharge monitoring would be performed to demonstrate continued compliance with the management of migration objective and the continued protection of public health and the environment.

4.4.4.6. Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative reduces the toxicity, and volume of contaminated groundwater through extraction and treatment. In addition, operation of the new extraction well(s) will likely result in control of the groundwater plume, reducing mobility.

4.4.4.7. Implementability

This alternative is straightforward to implement. The technologies necessary are available and well-proven for use. Space would need to be identified for construction of the new treatment plant in proximity to the new extraction wells. This would require agreement with the Town.

4.4.4.8. Cost

The cost for this alternative is presented in **Table 4.4-4**. The capital cost estimate includes re-piping the existing MWSWs Butters Row 1 and 2 and construction of a new treatment plant with pretreatment and UV-oxidation for treatment of the extracted groundwater. Annual cost estimates include monitoring costs, O&M of the groundwater extraction and treatment systems, and 5-year site reviews. The total cost for Alternative GW 4 is $51,380,000 with a total present worth of $19,872,000.

4.4.5 Alternative GW 5: Groundwater In-situ Biological Treatment

4.4.5.1. Components of Alternative GW 5

Alternative GW 5 consists of the following major components:

- Institutional Controls
- Installation of Propane Biosparging Wells and System Equipment

- Groundwater Monitoring at Existing and New Monitoring Wells
- 5 Year Site Reviews

Institutional Controls. Deed covenants restricting prohibiting installation of wells other than for groundwater monitoring would be put into place and verified to prevent receptor contact with groundwater.

Installation of Propane Biosparging Wells and System Equipment. In this alternative, a propane biosparge barrier would be installed perpendicular to groundwater flow along the access road used to install GW-65S. Spacing for the sparge wells is assumed to be 25 feet here but would need to be confirmed. A propane injection system will be constructed including a compressor, controls and associated piping, and an enclosure will be installed to contain the above ground components.

Groundwater monitoring. Concentrations of COCs in groundwater would be monitored through sampling at existing and new monitoring wells.

Five-year site reviews. Five-year site reviews would be performed in the same manner as described in Alternative GW 2A.

4.4.5.2. Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment by preventing receptor contact with COCs in groundwater through institutional controls and by treating groundwater in-situ. Groundwater would be treated in-situ through biodegradation facilitated by propane biosparging. Groundwater concentrations would be monitored to verify water quality.

4.4.5.3. Compliance with ARARs

This alternative complies with ARARs. Groundwater would be treated in-situ to meet chemical-specific ARARs. Groundwater monitoring and treatment processes would be in accordance with location- and action-specific ARARs.

4.4.5.4. Short-term Effectiveness

This alternative is not effective in the short term in that it will not meet the groundwater-specific IAO during the time of construction or implementation. This alternative will prevent exposure via potable use to COCs at concentrations exceeding the cancer risk of 1×10^{-4} or HI greater than 1 immediately through institutional controls.

4.4.5.5. Long-term Effectiveness and Permanence

If the technology can be demonstrated it could be effective in the long-term. Once constructed, the propane biosparging system would then provide a reliable long-term groundwater migration control solution. Treatment of groundwater in-situ would continue until the identified groundwater COCs meet drinking water standards. Maintenance of the propane biosparge system will be required for the duration of its use. O&M of the treatment system has been included in cost estimating. Once complete, this remedy is permanent. O&M of the sparge system would continue until the identified groundwater COCs meet drinking water standards. Groundwater monitoring would be performed to monitor the groundwater quality.

4.4.5.6. Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative reduces the toxicity, and volume of contaminated groundwater through biodegradation of NDMA in-situ.

4.4.5.7. Implementability

This alternative is moderately difficult to implement. The technologies necessary are available and have been shown to work at the field-scale (Hatzinger and Lippincott, ESTCP 2015). However, a laboratory treatability study using site materials—soils and groundwater—to evaluate site-specific biodegradation rates of NDMA and/or pilot scale testing would need to be conducted prior to design and implementation. Additionally, space would need to be identified for construction of the propane biosparging compressor and associated piping and equipment. It is practically feasible to construct the system including a new building to house the compressor and associated propane biosparging equipment.

4.4.5.8. Cost

A cost estimate for Alternative GW 5 has not been prepared as the costs are dependent upon laboratory treatability study and/or pilot scale testing, and further evaluation of the technology.

4.5 Containment Area Alternatives

Based on USEPA review of the OU1/OU2 FS and the OU3 FS (Amec Foster Wheeler, 2018c and d), the USEPA specifically requested that this IAFS include capping and soil removal alternatives to be evaluated for the Containment Area. However, as discussed in Subsection 3.2.4.3, there are no waste materials remaining, and no unacceptable risk to receptors associated with subsurface soil (up to 10 feet below ground surface) within the Containment Area Slurry Wall.

Although the USEPA requested a soil removal alternative be included in this IAFS, there is no reason to justify this type of an alternative, and therefore, a soil removal alternative was eliminated during the screening of alternatives presented in Section 3.2.4. Therefore, the remainder of this section discusses the capping alternative.

4.5.1 Alternative CA 2: Capping, Equalization Window Closure, and Institutional Controls

Based on assessment of the chemical data for the soils located within the confines of the Slurry Wall Containment Area, a permanent cap is proposed that would comply with RCRA Subtitle D requirements, which would minimize infiltration to levels consistent with the hydraulic properties of the Containment Area. Since the Containment Area does not have a constructed bottom liner, and the objective of the slurry wall is to isolate groundwater, the cap will have a hydraulic conductivity comparable to the slurry wall. In this alternative, the existing equalization window would be removed or grouted in-place.

4.5.1.1. Components of Alternative CA 2

This alternative involves replacing the temporary cap over the Containment Area with a permanent cap that complies with RCRA Subtitle D requirements (40 CFR Part 258.60), which are to:

- Have a permeability less than or equal to the permeability of the bottom liner system or natural subsoils present, or a permeability of no greater than 1E-05 cm/sec, whichever is less;
- Minimize infiltration through the area by using an infiltration layer that contains a minimum of 18 inches of earthen material; and
- Minimize erosion of the final cover by using an erosion layer that contains a minimum of 6 inches of earthen material capable of sustaining plant growth.

Alternative CA 2 consists of the following components:

- Institutional controls
- Equalization window removal
- Cap construction over the Slurry Wall Containment Area
- Long-term operation and maintenance
- Five-year site review

Institutional controls. Deed covenants are currently in effect to provide restrictions on future activities and future use of the Property. The existing deed covenants would need to be modified to include language to limit and restrict future subsurface activities within the confines of the Slurry Wall Containment Area.

Equalization window removal. The existing equalization window on the west side of the Containment Area, consisting of an approximate 10 foot by 40 foot opening in the slurry wall filled with crushed stone, would be removed by sealing and grouting to eliminate the flow of groundwater through the slurry wall.

Cap construction over the Slurry Wall Containment Area. The temporary cap would be removed followed by installation of a cap generally meeting RCRA Subtitle D requirements. The objective of the cap is to replace the temporary cap over the Slurry Wall Containment Area with a cap to continue to permanently minimize infiltration into the Containment Structure. Subtitle D requires that a final cover minimize infiltration and erosion through construction of an infiltration layer of earthen material that has a permeability less than or equal to the permeability of the bottom liner system or natural soils present or a permeability no greater than 1E-5 centimeters per second (cm/sec), whichever is less. The Containment Area does not have a synthetic bottom liner and therefore the infiltration barrier can be constructed from soil and designed to meet the required minimum permeability. Note that the existing slurry wall has an effective permeability of approximately 1E-8 cm/sec. Therefore, the cover system would be designed as a composite cover (geomembrane over GCL) to meet this lower permeability requirement.

Prior to construction of the RCRA Subtitle D cap, the equalization window would be removed as described previously. Additionally, the area would be re-graded by cut and fill activities to create positive grades to allow surface water drainage to a perimeter drainage ditch that would carry surface water to the existing retention basin.

A typical cross-section of the proposed RCRA Subtitle D cap, as shown on Figure 4.5-1, is assumed to be composed of the following layers from depth to surface:

- compacted subgrade fill
- 12 inches of soil
- geosynthetic clay liner
- linear low-density polyethylene geomembrane
- geocomposite drainage layer
- 18 inches of soil cover

- vegetative layer with 6 inches of topsoil

The proposed RCRA Subtitle D cap does not need or include a gas venting layer. Typical waste materials that would degrade over time and create methane gas are not present within the Containment Structure. Therefore, a gas venting layer has not been included. If this type of a cap is selected as the final remedy, the actual cap configuration would be established in the ROD and remedial design.

Construction of the Subtitle D cap is estimated to take approximately six months to complete.

Long-term operation and maintenance. Periodic inspections of the RCRA Subtitle D cap would be conducted to verify the structural integrity of the cap is not compromised. Any damaged areas of the cap would be repaired as necessary to maintain the integrity of the cap. Similar to the inspections conducted for the current temporary cap over the Containment Area, the inspections for the RCRA Subtitle D cap are assumed to be conducted on a quarterly basis and the results would be reported in SASRs that are submitted to the USEPA. For cost estimating purposes to support this IAFS, annual O&M inspections have been assumed for 30 years.

Five-year site review. CERCLA requires that any remedial action that results in contaminants remaining on-site at concentrations above those allowing unlimited exposure and unrestricted use must be reviewed at least every five years. During five-year site reviews, an assessment is made as to whether the implemented remedy continues to be protective of human health and the environment, or whether the implementation of additional remedial action is appropriate. The USEPA document Comprehensive Five-Year Review Guidance (USEPA, 2001) provides guidance on the performance of five-year site reviews. For cost estimating purposes to support this FS, five-year site reviews have been assumed for 30 years.

4.5.1.2. Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment by removing the equalization window and replacing the temporary cap over the Containment Area structure with a RCRA Subtitle D cap would continue to permanently minimize infiltration into the Slurry Wall and Containment Area Structure.

4.5.1.3. Compliance with ARARs

ARARs for this alternative are presented in **Tables 2.1-8 through 2.1-10**. This alternative would comply with ARARs. Site remediation workers would wear appropriate PPE for the protection of worker safety. Although OSHA standards are not considered ARARs, the requirements, standards, and regulations of OSHA will be complied with during the remedial activities. Engineering controls would be employed to comply with RCRA standards applicable to generation, transportation, and storage of hazardous waste, as well as federal and state solid waste disposal regulations.

The objective of the cap is to replace the temporary cap over the Slurry Wall Containment Area with a cap to continue to permanently minimize infiltration into the Containment Structure. Historical disposal areas within the Containment Structure have been removed and waste materials are not currently present in shallow soil (e.g., up to 10 feet deep) within the Containment Area. The DAPL surface within the Containment Area is approximately 35 ft below ground surface and deed covenants are currently in place prohibiting intrusive activities within the Containment Structure.

Additionally, this alternative would be designed and implemented to minimize potential impacts to floodplain or wetland areas. If remediation in floodplains or wetlands is required, restoration activities would be implemented to comply with the identified location-specific ARARs.

4.5.1.4. Short-term Effectiveness

This alternative includes installing a RCRA Subtitle D cap over the Slurry Wall and Containment Area Structure. This alternative would be protective of human health and the environment upon completion of the active, construction-related activities associated with this remedy. Potential short-term risks to on-site workers involved in the remedial activities would be minimized by conducting the work in accordance with a site-specific health and safety plan.

4.5.1.5. Long-term Effectiveness and Permanence

This alternative provides long-term effectiveness by installing a RCRA Subtitle D cap over the Slurry Wall and Containment Area Structure. As discussed previously, the objective of the cap is to replace the temporary cap over the Slurry Wall Containment Area with a cap to continue to permanently minimize infiltration into the Containment Structure.

4.5.1.6. Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative provides a reduction in mobility of contaminants by constructing a permanent RCRA Subtitle D cap over the Slurry Wall and Containment Area Structure. This alternative does not provide any reduction in toxicity or volume of contaminants, and does not involve any treatment technologies.

4.5.1.7. Implementability

The major component of this alternative is construction of a permanent RCRA Subtitle D cap over the Slurry Wall and Containment Area Structure. The technologies used for this alternative are available and sufficiently demonstrated for use at the site. The necessary equipment and materials are readily available.

4.5.1.8. Cost

The cost estimate for this alternative is presented in **Table 4.5-1** and includes:

- Institutional controls
- Equalization window removal
- Cap construction over the Slurry Wall Containment Area
- Long-term operation and maintenance
- Five-year site review

Cost estimates were developed using RS Means construction cost data, as well as professional judgement and experience on similar types of construction and remediation projects

Assuming remedial activities can be conducted simultaneously as much as possible, the overall estimated duration to complete this alternative is approximately six months.

The capital costs for Alternative CA 2 are estimated to be approximately $2,365,000. The total cost for Alternative CA 2 is estimated to be $3,178,000. The total present worth for Alternative CA 2 is $32,924,000.

4.6 Comparative Analysis of Alternatives

In this section, alternatives for each medium are compared to one another by each of the evaluation criteria. **Tables 4.6-1, 4.6-2, 4.6-3, and 4.6-4** present summaries of the comparative analysis for LNAPL Alternatives, DAPL Alternatives, Groundwater Alternatives, and Containment Area Alternatives, respectively.

4.6.1 Comparative Analysis of LNAPL Alternatives

This section presents the comparative analysis for the LNAPL Alternatives:

- LNAPL 1: No Action

- LNAPL 2: Manual Recovery
- LNAPL 3: Continual Mechanical Recovery
- LNAPL 4: MPE

4.6.1.1. Overall Protection of Human Health and the Environment

Alternative LNAPL 1 is protective of human health and the environment because it does include existing technologies to remove LNAPL and existing institutional controls to prevent receptors' contact with COPCs. Alternative 1 does not enhance LNAPL removal. Alternatives LNAPL 2, LNAPL 3, and LNAPL 4 are protective of human health and the environment. They include institutional controls to prevent receptors' contact with COPCs during the time LNAPL is being recovered from the Site.

4.6.1.2. Compliance with ARARs

Alternative LNAPL 1 currently complies with ARARs. Alternatives LNAPL 2, LNAPL 3, and LNAPL 4 would be designed and implemented to comply with ARARs. Recovered LNAPL would be disposed of in accordance with state and federal hazardous waste regulations.

4.6.1.3. Short-term Effectiveness

Alternatives LNAPL 1 is not effective in the short-term because it does not meet the IAO to enhance the recovery of LNAPL during the time of construction or implementation. Alternatives LNAPL 2, LNAPL 3 and LNAPL 4 are effective in the short-term; LNAPL recovery would be enhanced during the time of implementation for these alternatives.

4.6.1.4. Long-term Effectiveness and Permanence

Alternatives LNAPL 1 is not effective in the long term. It does not meet the IAO to enhance recovery of LNAPL. Alternatives LNAPL 2, LNAPL 3 and LNAPL 4 are effective in the long-term. In Alternative LNAPL 2, recovery would be enhanced by adding passive absorbent socks. Alternative LNAPL 3, recovery would be enhanced by adding continual automatic skimming of LNAPL at the Site. In Alternative LNAPL 4, recovery would be enhanced through MPE. In both Alternatives LNAPL 3 and 4, 5-years of post-recovery monitoring would confirm that LNAPL was recovered to the extent practicable.

4.6.1.5. Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative LNAPL 1 does reduce toxicity, mobility, or volume due to current operations. Alternatives LNAPL 2, LNAPL 3, and LNAPL 4 enhance the reduction of volume and mobility by removing additional LNAPL from the Site. They reduce toxicity by removing LNAPL as a source of COPCs to groundwater. Reductions to toxicity, mobility, and volume are achieved through removal, not treatment.

4.6.1.6. Implementability

Alternative LNAPL 1 requires no implementation. Alternative LNAPL 2 requires only the development of a formal workplan addendum for recovery and monitoring; LNAPL is already being manually recovered at the Site. Alternatives LNAPL 3 and LNAPL 4 are straightforward to implement. The technologies are readily available and sufficiently demonstrated for use.

4.6.1.7. Cost

The total present worth of each LNAPL alternative is listed below. Alternative LNAPL 2 is the highest-cost alternative, with LNAPL 3 being of similar cost. Alternative LNAPL 4 is about half as costly as LNAPL 2 and LNAPL 3.

LNAPL 1: No Action	$ 0
LNAPL 2: Manual Recovery	$ 22,000
LNAPL 3: Continual Mechanical Recovery	$131,000
LNAPL 4: MPE	$190,000

4.6.2 Comparative Analysis of DAPL Alternatives

This section presents the comparative analysis of the following DAPL alternatives:

- DAPL 1: No Action
- DAPL 2A: DAPL Extraction in the Off-PWD DAPL Pool
- DAPL 2B: DAPL Extraction in the On-Property DAPL Pool
- DAPL 2C: DAPL Extraction in the Main Street DAPL Pool

4.6.2.1. Overall Protection of Human Health and the Environment

Alternative DAPL 1 is not protective of human health and the environment; it includes no institutional controls to prevent receptors' contact with DAPL. Alternatives DAPL 2A, DAPL 2B, and DAPL 2C are protective of human health and the environment. They include institutional controls to prevent receptors' contact with DAPL and include DAPL extraction to the extent practicable.

4.6.2.2. Compliance with ARARs

Alternative DAPL 1 does not comply with ARARs. Alternatives DAPL 2A, DAPL 2B, and DAPL 2C would be designed and implemented to comply with ARARs. They include disposal to be completed in accordance with state and federal hazardous waste regulations and remedy construction work in sensitive areas such as wetlands to be performed with minimal disturbance and post-construction restoration.

4.6.2.3. Short-term Effectiveness

Alternative DAPL 1 is not effective in the short term. Alternatives DAPL 2A, DAPL 2B, and DAPL 2C are effective in the short term; they will begin removing DAPL during the time of implementation. Institutional controls will prevent human exposure to DAPL during the alternatives' implementation. DAPL extraction has already been demonstrated effective by the DAPL Pilot Test.

4.6.2.4. Long-term Effectiveness and Permanence

Alternative DAPL 1 is not effective in the long term. Alternatives DAPL 2A, DAPL 2B, and DAPL 2B are effective in the long term. These alternatives permanently remove DAPL and its associated COPCs to the extent practicable. Long term O&M and institutional controls prevent human exposure during the time of DAPL extraction.

4.6.2.5. Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative DAPL 1 does not reduce toxicity, mobility, or volume. Alternatives DAPL 2A, DAPL 2B, and DAPL 2C reduce the volume of COPCs by removing DAPL and disposing in accordance with RCRA hazardous waste disposal regulations. They also reduce mobility and toxicity by removing DAPL as a source of COPCs to overlying groundwater.

4.6.2.6. Implementability

Alternative DAPL 1 has no components to implement. Alternatives DAPL 2A, DAPL 2B, and DAPL 2C are straightforward to implement. The technologies, equipment, and materials used for these alternatives are readily available and sufficiently demonstrated for use.

4.6.2.7. Cost

The total present worth of each DAPL alternative is listed below. Alternative DAPL 2C is the highest-cost alternative, with DAPL 2A and 2B being of more similar cost.

DAPL 1: No Action	$ 0
DAPL 2A: DAPL Extraction in Off-PWD DAPL Pool	$ 2,487,000
DAPL 2B: DAPL Extraction in On Property DAPL Pool	$ 1,012,000
DAPL 2C: DAPL Extraction in Main Street DAPL Pool	$ 26,091,000

4.6.3 Comparative Analysis of Groundwater Alternatives

4.6.3.1. Overall Protection of Human Health and the Environment

Alternative GW 1, No Action, is not protective of human health and the environment. Alternatives GW 2A, GW 2B, GW 3, GW 4 are protective of human health and the environment. Alternative GW-5 requires additional bench and pilot scale testing to demonstrate protectiveness. Alternatives GW 2A, GW 2B, GW 3, and GW 4 all involve extraction and treatment of NDMA-impacted groundwater, to control downgradient migration, and prevent exposure to COCs in groundwater through institutional controls. Alternative GW 5 involves in-situ treatment of NDMA in groundwater, and prevents exposure to COCs in groundwater through institutional controls.

4.6.3.2. Compliance with ARARs

Alternative GW 1 does not comply with ARARs. Alternatives GW 2A through GW 5 would be designed and implemented to comply with ARARs.

4.6.3.3. Short-term Effectiveness

Alternatives GW 1 is not effective in the short term; it will not meet IAOs during the time of construction or implementation. Alternatives GW 2A through GW 5, are effective in the short term; they will meet the groundwater-specific IAO during the time of construction or implementation. Alternative GW-5 requires additional bench and pilot scale testing to demonstrate effectiveness.

4.6.3.4. Long-term Effectiveness and Permanence

Alternative GW 1, No Action, is not effective in the long term. Alternative GW 1 does not include a mechanism to monitor progress for natural attenuation, nor does it include 5-Year site reviews to evaluate continued effectiveness. Alternatives GW 2A through GW 4 are effective in the long-term at meeting the groundwater-specific IAO. Alternative GW-5 requires additional bench and pilot scale testing to demonstrate protectiveness.

4.6.3.5. Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative GW 1, No Action does not reduce toxicity, mobility, or volume. Alternatives GW 2A through GW 4 reduce toxicity, mobility, and volume of COCs in groundwater through extraction and treatment. Alternative GW 5 reduces toxicity, mobility, and volume of COCs in groundwater through in-situ treatment. Alternative GW-5 requires additional bench and pilot scale testing.

4.6.3.6. Implementability

Alternative GW 1, No Action, has no components to implement. Alternatives GW 2A through GW 5 are relatively straightforward to implement with proven technologies. Alternatives GW 2A and GW 2B will require the addition of UV-oxidation treatment units to the municipal plant. Alternatives GW 3 and GW 4 will require the construction of a new water treatment plant. Alternative GW 5 will require the installation of propane sparge wells and associated pipping, compressor, and appurtenances.

4.6.3.7. Cost

The total present worth of each groundwater alternative is listed below.

GW 1: No Action	$ 0
GW 2A: Groundwater Extraction via MWSWs with Treatment for Potable Use by Additions to Municipal Water Treatment Plant	$17,330,000
GW 2B: Groundwater Extraction via MWSWs with Treatment for Surface Water Discharge by Additions to Municipal Water Treatment Plant	$23,565,000
GW 3: Groundwater Extraction via New Wells and Treatment via New Water Treatment Plant for Surface Water Discharge	$13,503,000
GW 4: Groundwater Extraction via Butters Row MWSWs and Treatment via New Water Treatment Plant for Surface Water Discharge	$19,872,000

4.6.4 Comparative Analysis of Containment Area Alternatives

This subsection presents the comparative analysis for the following Containment Area remedial alternatives:

- Alternative CA 1: No Action
- Alternative CA 2: Capping, Equalization Window Closure, and Institutional Controls

4.6.4.1. Overall Protection of Human Health and the Environment

Alternative CA 1 is not protective of human health and the environment. Although there is no unacceptable risk to receptors due to exposure to shallow subsurface soil within the Containment Area, the No Action alternative does not include any actions to replace the deteriorating temporary cap over the Containment Area, which would be necessary to continue to minimize infiltration into the Containment Area.

Alternative CA 2 would be protective of human health and the environment by removing the equalization window and replacing the temporary cap over the Containment Area structure with a RCRA Subtitle D cap would continue to permanently minimize infiltration into the Slurry Wall and Containment Area Structure.

4.6.4.2. Compliance with ARARs

Alternative CA 1 does not comply with ARARs. Alternative CA 2 would be designed and constructed to comply with the identified ARARs, including RCRA Subtitle D requirements for the cap to be installed over the Containment Area.

4.6.4.3. Short-term Effectiveness

The No Action alternative is not protective in the short-term because it does not include any actions to replace the deteriorating temporary cap over the Containment Area, which would be necessary to continue to minimize infiltration into the Containment Area. Alternative CA 2 includes installing a RCRA Subtitle D cap over the Containment Area, which would be effective at providing protection to receptors upon completion of the active construction-related activities associated with the remedy. Potential short-term risks to on-site workers involved in the remedial activities would be minimized by conducting the work in accordance with a site-specific health and safety plan.

4.6.4.4. Long-term Effectiveness and Permanence

The No Action alternative is not protective in the long-term because it does not include any actions to replace the deteriorating temporary cap over the Containment Area, which would be necessary to continue to minimize infiltration into the Containment Area. Alternative CA 2 includes installing a RCRA Subtitle D cap over the Containment Area, which would be effective at providing protection to receptors upon completion of the active construction-related activities associated with the remedy. Alternative CA 2 also includes long-term O&M activities and performance of Five-Year Site Reviews to evaluate the continued long-term effectiveness of the remedy.

4.6.4.5. Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives CA 1 and CA 2 do not include any treatment technologies, and do not provide any reduction in toxicity or volume of contaminants. Capping of the Containment Area, in conjunction with the existing slurry wall and removal of DAPL within the Containment Area, would provide a reduction in mobility of contaminants.

4.6.4.6. Implementability

The No Action alternative has no components to implement. Alternative CA 2 includes closure of the equalization window in the existing slurry wall and installation of a RCRA Subtitle D cap. The technologies used for this alternative are available and sufficiently demonstrated for use at the site. The necessary equipment and materials are readily available.

4.6.4.7. Cost

The total present worth of the Containment Area alternatives is listed below.

CA 1: No Action	$ 0
CA 2: Capping, Closure of the Equalization Window, and Institutional Controls	$2,924,000

5.0 RECOMMENDED ALTERNATIVES

The preferred LNAPL Alternative is LNAPL 2 due to its overall protectiveness of human health and the environment, compliance with ARARs, short and long-term effectiveness, reduction of LNAPL mobility and volume, simplicity in implementation and low cost.

The preferred DAPL Alternatives are DAPL 2A, DAPL 2B, and DAPL 2C, which meets USEPA's objective of removing DAPL from all three DAPL pools to the extent practicable. Each of these alternatives have been developed to take advantage of maximum gravity drainage rates which results in an aggressive approach for each pool. DAPL from all pools would be removed within a similar timeframe. These alternatives are preferred due to their overall protectiveness of human health and the environment, compliance with ARARs, short and long-term effectiveness, reduction of DAPL toxicity, mobility and volume

The preferred groundwater alternative is Alternative GW-2A because it is the only alternative that meets both the IAO to control down gradient migration and to return groundwater to productive use. However, this alternative will require Community Acceptance by the public and the Town. If this alternative is not accepted it would not be implementable. In that case the next preferred alternative would be Alternative GW-3 where new wells would be installed with a new treatment plant to management migration of downgradient groundwater. This alternative would allow the town to continue use of the Butters Row Treatment Plant to treat water from the Shawsheen well and provide a more efficient means of groundwater capture. Each of these alternatives provide for overall protectiveness of human health and the environment, compliance with ARARs, short and long-term effectiveness, reduction of dissolved constituent toxicity, mobility and volume by managing migration in downgradient groundwater.

The preferred Containment Area Alternative is CA 2, which is protective of human health and the environment, would be designed and constructed to comply with ARARs, provides short-term and long-term effectiveness by providing hydraulic isolation, preventing exposure to Containment Area soils and is readily implementable.

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FIGURES

TABLES

APPENDIX A
CONTAINMENT AREA SOIL DATA

APPENDIX B
DISTRIBUTION OF PRIMARY CONTAMINANTS OF CONCERN

APPENDIX C
POTENTIOMETRIC MAPS OCTOBER 1995